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PHILADELPHIA LONDON

PHYTOPATHOLOGY

VOLUME XII NUMBER 4

APRIL, 1922

BLACK ROT OF CARROTS CAUSED BY ALTERNARIA RADICINA N. SP.[1]

FRED C. MEIER, CHARLES DRECHSLER, AND E. D. EDDY

WITH PLATE XI AND TWO FIGURES IN THE TEXT

During the winter of 1918–19 dealers at the New York market frequently complained of heavy losses due to decay of carrots in transit and storage, particularly in the case of stock that had been held in storage on Long Island farms. For this reason, early in April a trip was made by one of the writers to farms in the vicinity of Peconic and Orient, New York, for the purpose of studying local storage conditions.

The farmers living in this section of Long Island usually store their carrots in one of three ways; either in narrow pits, in mounds above ground or in cellars. During the course of the investigation it was found that irrespective of the method of storage used, a few of the carrots in most lots examined were either partially or entirely destroyed by a characteristic black rot. Examination of stock stored on farms in Danvers and South Peabody, Massachusetts, brought to light the fact that this disease is prevalent in these communities also.

The trouble, as it occurs on the root, is characterized by a progressive softening and blackening of the tissues. Infection seems to occur frequently at the crown, as a result of which the black decay extends down the core of the carrot, as shown by the photograph in plate XI, A. Many cases have also been observed where the decay had originated at other points on the surface of the carrot. Observations made on the crop in storage in the several localities mentioned in this paper indicate that although the disease is by no means as serious as that caused by *Sclerotinia sp.*, it is, nevertheless, responsible for considerable loss each winter.

[1] The work discussed in this paper was done as a coöperative enterprise between the Office of Cotton, Truck, and Forage Crop Disease Investigations and the Bureau of Markets, United States Department of Agriculture, partly at Washington, D. C., and, through the courtesy of the Director, Dr. G. S. Gager, partly in the laboratories of the Brooklyn Botanic Garden, Brooklyn, N. Y.

On the above mentioned field trips, specimens were collected at Peconic, Southold, and Orient, New York, and at Danvers and Peabody, Massachusetts. The fungus was isolated from these specimens by transferring small pieces of infected tissue from a freshly exposed surface to hard potato agar tubes by means of sterilized instruments. Pure cultures of an undescribed fungus, which was later identified as a new species of Alternaria, were obtained from each carrot affected by the black rot. The fungus developed rapidly on potato agar, forming a dense, black mycelial growth over the surface, and after a few days produced conidiophores and conidia in great numbers.

INOCULATIONS OF CARROTS

In order to determine the relation of this organism to the decayed tissue from which it was isolated, a series of inoculations were made. Three dozen sound carrots were washed thoroughly with water and then subjected to surface sterilization. This consisted of washing the root quickly with 95 per cent alcohol, this treatment followed immediately by application of a mercuric chloride solution (1 to 1000). After the latter solution had been allowed to act for 5 minutes, the carrots were rinsed thoroughly in sterilized water. Three incisions were then made on each carrot by means of a flamed scalpel, and small masses of mycelium and spores taken from pure cultures of the fungus were inserted in the incisions on 28 specimens. The remaining 8 were not inoculated but were retained to serve as controls during the experiment. All of the carrots, both those which had been inoculated and the controls, were then placed in paraffin paper bags and held at room temperature for 3 weeks.

The decay developed rather slowly at the temperature of the laboratory during April. After 48 hours only a very small soft black spot had developed around the incisions on the inoculated carrots. No sign of decay had appeared around those on the control carrots. In fact, these 24 incisions closed up rapidly, drying out slightly, and the carrots remained uninfected during the experiment.

Twenty-one days after the inoculations were made, the carrots were removed from the paper bags and observations and photographs were made. Re-isolations from the decayed spots, carried out in the same way as the original isolations from the naturally infected roots, gave pure cultures of the Alternaria that was used for inoculation purposes. Every inoculation of the 84 resulted in infection, the characteristic black rot being produced in all cases. At the end of 3 weeks the decayed spots had developed to about an inch or more in diameter on the surface and half an inch to an inch in depth into the tissues of the root. Each spot was more or less depressed and its surface entirely covered by a

dense black mat of aerial mycelium with conidiophores bearing typical spores, singly or in groups in the manner of fungi generally referred to the genus Macrosporium. The tissues beneath the spot were softened and jet black in color. Plate XI, B, shows a carrot with 3 decayed spots resulting from inoculations. This should be compared with Plate XI, C, a photograph of one of the control carrots, which shows very clearly 2 uninfected incisions. Plate XI, D, is a photograph of median longitudinal section of the inoculated carrot shown in figure B. This last photograph shows the extent to which the fungus developed in the tissues of the root during a period of 21 days at room temperature.

INOCULATIONS OF THE FOLIAGE

During the summer of 1919, field inoculation experiments were carried out, to determine whether this fungus was able to cause a disease of the leaves as well as of the roots. It was also expected that such experiments would enable the writers to determine whether the black rot organism is related to *Macrosporium carotae* Ellis and Langlois, which causes a blight of the foliage.

Inoculations on the Danvers Half-long variety were made during cloudy weather in the last week in June. Spores from pure cultures of the black rot organism on potato agar were mixed with sterilized water and this suspension of spores was then brushed onto the foliage of the plants in two rows of carrots. Eight other rows of carrots in the experimental plot served as controls.

Within two weeks after inoculation, a disease had made its appearance on the inoculated plants. Small discolored areas appeared both on the leaves and the petioles. These spots were at first always brown in color, although in some cases they subsequently turned black. On the petiole the area of dead brown cells extended through the vascular tissues and thus cut off the water supply to the leaf. A wilt of the leaves resulted from these infections on the petioles. They turned yellow, then brown, and the conidia of the parasite developed in large numbers over the entire surface.

During the first month after the disease appeared on the inoculated rows, the control plants in the adjacent rows remained healthy and uninfected. But during early fall the fungus spread to these plants, with the result that the entire plot showed foliar lesions or entirely blighted leaves. The outer leaves of the plants blighted and fell to the ground, forming a mat of dead foliage between the rows.

Isolations were made from leaf lesions and from blighted leaves taken from these infected plants. Two methods were used: (1) spores were washed off in sterilized water and the suspensions thus obtained were plated out in Petri dishes; and (2) pieces of diseased tissues were sterilized by dipping in alcohol followed by mercuric chloride (1–1000), and then

placed on potato agar in Petri dishes. In either case the fungus obtained was similar in every way to that used in making the inoculations. Pure culture transfers were then made from these plates and the fungus was inoculated into carrots, the same precautions being observed against infections from the outside as outlined above for the previous experiments. The typical black rot developed around each inoculation.

Carrots which showed the blighted foliage were dug up, the tops removed to within an inch of the crown, and the entire surface of the root sterilized with alcohol and mercuric chloride. These roots were then placed in sterilized glass jars and held at room temperature. The same fungus again developed from the bases of the infected petioles and extended down into the center of the root, causing a black rot of the tissues.

Since the infection experiments on the leaves showed that the same organism which causes the black rot of the roots may also cause a disease of the foliage, a careful investigation was made of plants growing in the various fields where the carrots which showed this black rot last winter had been grown during the summer of 1918. Plants showing blighted leaves were collected on the farms at Peconic and Orient, New York, as well as Danvers and South Peabody, Massachusetts, and examined, in the laboratory for the presence of conidia similar to those developed on the inoculated plants. In every case conidia of a Macrosporium were found on the diseased leaves but these conidia did not resemble those developed on the inoculated plants but were readily recognizable as belonging to *Macrosporium carotae* Ellis and Langlois, being characterized by the presence of long, apical sub-hyaline appendages.

Many attempts were made during the summer and fall of 1919 to isolate *Macrosporium carotae* and to obtain pure cultures which might be used for inoculation purposes. While this fungus grew on potato agar and produced typical conidia, the development in culture was very sparse as compared with that of the black rot organism. In fact, the season passed before cultures suitable for inoculation work could be obtained.

THE FUNGUS

The conidial fructifications of the fungus developing on the surface of inoculated carrots, or in pure culture on agar media relatively rich in organic nutrients, as for example, potato dextrose agar, are of the type usually referred to the genus Macrosporium. On the substrata mentioned the production of aerial mycelium is relatively rapid and abundant. From the fuliginous or brownish hyphae that largely compose the dense black mats of aërial growth, the sporophores arise as short branches often several times septate and distinguished by their dark brown color. They bear at the tip usually one or two and more rarely three spores; the latter are attached directly to the sporophore and show no tendency toward a catenulate habit.

It may be mentioned that when the fungus is cultivated on substrata encouraging a rapid and abundant development, growth comes to a standstill comparatively early, stopping not unusually within 10 to 15 days. Such cessation of growth is, of course, familiar enough to students of nearly every group of fungi, and finds some plausible explanation in the accumulation of toxins. Whatever the explanation may be, the fact is quite obvious that fructifications developing under the conditions described, although often very abundant, are frequently not especially well developed. Thus more satisfactory results can often be obtained by the use of media containing little organic nutrient material on which growth is relatively scant, but which permit the moderate number of sporophores to continue development during a much longer period.

The black rot fungus was accordingly grown on tap water agar and Beijerinck's agar, neither containing any organic nutrients except such as were accidentally introduced. Drying out of the agar was prevented by incubating the Petri dishes in damp chambers. Microscopic examination of the cultures showed that at the end of 60 days the fungus was still growing. The fructifications, while in other details similar to those found on the richer substrata, showed not infrequently a catenulate arrangement of the spores, usually regarded as the distinctive characteristic of the genus Alternaria (Fig. 1, B, C, D,). Proliferation of secondary spores usually occurred at the tip of the primary spores, which were modified to form short subhyaline beaks. Such modification was not observed in spores that had not given rise to secondary spores. Occasionally the secondary structure was produced from one of the segments other than the distal one, in which case a short hyaline lateral process quite similar to the terminal modification supported the secondary spore.

The spores developed on carrots are straight, clavate, ellipsoid, obovoid, or turbinate; light brown to dark brown and dark olivaceous when fully mature; from 3 to 7 times transversely septate, with a longitudinal septum dividing some or all of the transverse segments not occupying a terminal position; measuring usually from 17–20 × 34–51 μ. When developed on potato dextrose agar the spores generally measure considerably less. On tap water agar or Beijerinck's agar the spore measurements approximate those on the carrot, although showing in general a somewhat greater degree of variability. Spores like those shown in figure 1, A 1–3, probably represent nearly the maximum dimensions attained by the species,—width 22μ (Fig. 1, A 1–3),—length 64 μ (Fig. 1, A 2)—as well as nearly the greatest degree of septation, showing eight cross walls and two longitudinal septa in some of the transverse segments.

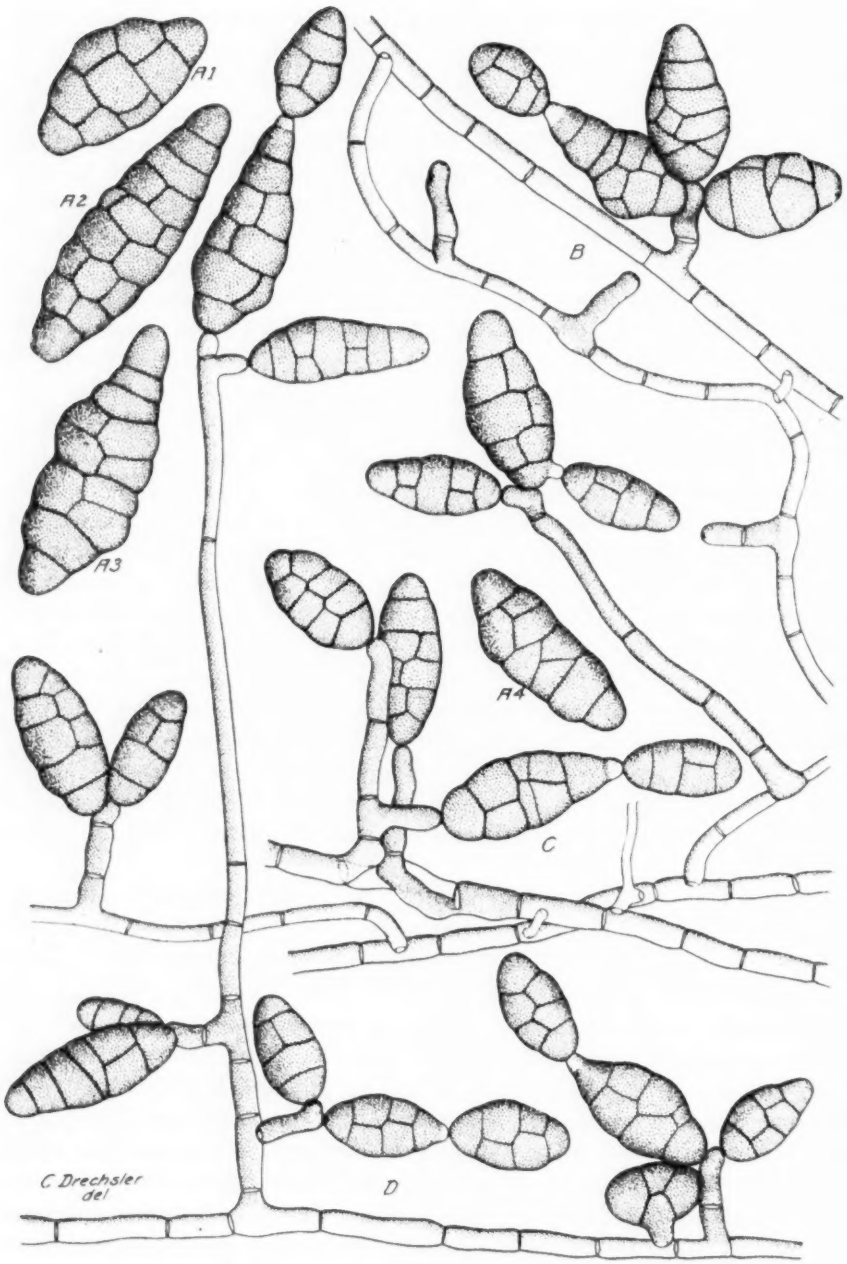


FIG. 1. *Alternaria radicina* from a culture on tap water agar incubated at a temperature of 15 to 20° C. x 535. A, 1–3. Spores illustrating approximate maximum dimensions and approximate maximum degree of septation. A, 4. Spore of average dimensions. B, C. D. Portions of mycelium showing darker colored short sporophores arising from more hyaline hyphae, the catenulate arrangement of some spores, and the tendency of the hyphae to anastomose with each other.

No report could be found in the literature of a root rot of carrots caused by a species of Alternaria, Macrosporium, or any of the allied genera. But Ellis and Langlois[1] described from Louisiana a species of Macrosporium as the cause of a disease of the foliage. This trouble has also been reported from New Jersey, Connecticut, Rhode Island, and other states. The causal organism was described as follows: "On living leaves of *Daucus carota*, to which it is very injurious. St. Martinsville, La., June, 1888, Langlois, No. 1327. Turning the leaves yellow, then brown, black and killing them entirely. Sterile hyphae erect, at first simple, straight, brown and septate, finally somewhat branched above, and 80 to 100 μ high by 4 to 6 μ thick. Conidia clavate, brown, 5 to 7 septate, with one or two of the upper cells longitudinally septate, 55 to 70 μ by 12 to 14 μ slender (1-½ to 2 μ thick), permanent pedicels 80 to 110 μ long."

An examination of type material of *Macrosporium carotae*, as well as of fresh material collected in New Jersey and in Washington, D. C., showed that this fungus is specifically distinct from the Alternaria species found destructive to the root. Figure 2, F 1–11, shows the conpicuous "pedicel" of the conidia of *Macrosporium carotae* developing on the leaves. It may attain a length of 300 μ (Fig. 2, F 4), bear one or two branches (Fig. 2, F 4, 7, 8), and show septa varying in number from one to ten (Fig. 2, F. 6); although more usually much shorter, without branches, and provided with but 3 or 4 septa. The description quoted above would seem to indicate that Ellis considered that portion of the spore designated as the pedicel as the lower end. Since the spore is attached to the conidiophore at its obtuse end, this "pedicel" should be considered as an appendage or prolongation of the terminal cell of the conidium.

In size of spore a much greater difference obtains between the fungus on the root and *M. carotae* than Ellis' description might suggest. The large spores of the latter, exclusive of the appendage, may attain a length of 100 μ or more (Fig. 2, F 1, 2, 4), a width of 30 μ (Fig. 2, F 1, 2), and show from 9 to 11 transverse septa with 2 or even 3 longitudinal septa further dividing the transverse segments. The cultural characters of the two fungi furnish another easy means of distinguishing them, as *M. carotae* produces, on all the kinds of media on which its cultivation was attempted, only very scant growth, and that consisting largely of colorless submerged mycelium; whereas, as has been pointed out, the fungus causing black rot produces considerable growth, both submerged and aerial, grayish black or bluish black, even on media almost devoid of organic food material.

[1] Ellis, J. B., and Langlois, A. B. New species of Louisiana fungi. Journal of Mycology **6**: 35–37. Mar., 1890. *P. 36. Macrosporium carotae*, n. sp.

The writers have never observed any catenulate tendency in the fructification of *M. carotae*. According to Elliott[1], the parasite is to be referred to the genus Alternaria, together with other forms possessing spores with a long beak. It is perhaps not impossible to suppose that if the fungus were grown on substrata more suitable than those employed by the writers, a catenulate habit might be manifested. In rather old material, spores may be found showing one or more short processes that have obviously functioned as sporophores in the production of secondary spores (Fig. 2, E 1–5). In nearly every case, however, such proliferation has apparently been associated with the degeneration of the primary spore, as is evidenced by the collapsed condition of many of its segments. It would appear advisable for the present, therefore, to retain the leaf blight fungus in the genus Macrosporium. The parasite causing black rot of the carrot is assigned to the genus Alternaria and is named *A. radicina* to indicate its relation to the root of its host, to which in nature it seems to be confined.

DIAGNOSIS

Alternaria radicina n. sp.

Aerial mycelium grayish black or bluish black, occurring in extensive mats composed of branching septate hyphae, varying in width from 2.5 to 7.0 μ; the wider hyphae more or less distinctly fuliginous, with constrictions associated with the septa; the narrower hyphae more nearly subhyaline, without perceptible constrictions at points of septation. Sporophores forming the terminations of the larger mycelial filaments, or more frequently arising as lateral branches of the latter at irregular but usually rather wide intervals, and at angles usually approaching a right angle; continuous or one to several times septate; fuliginous to dark brown or brown olivaceous, regularly darker than the axial hyphae from which they originate; when lateral, typically 4–5 × 10–25 μ; developing successively and in close proximity usually 2–3 primary spores, the points of attachment of which after disarticulation are marked by small dark scars. Spores borne directly on sporophores or more tardily in catenulate arrangement, or singly at apex of short sporophoric processes arising from a spore of the preceding order as attenuated prolongation of terminal segment, or as lateral outgrowth of nonterminal, most frequently of basal, segment; typically straight; clavate, ellipsoid, obovoid, or turbinate; light brown to dark brown or dark olivaceous when fully mature; from 3 to 8 times transversely septate, with a longitudinal segment dividing some or all of the segments not occupying a basal or apical position, and more infrequently

[1] Elliott, John A. Taxonomic characters of the genera Alternaria and Macrosporium. American Journal of Botany **4**: 439–476. *Pl. 19, 20.* 1917.

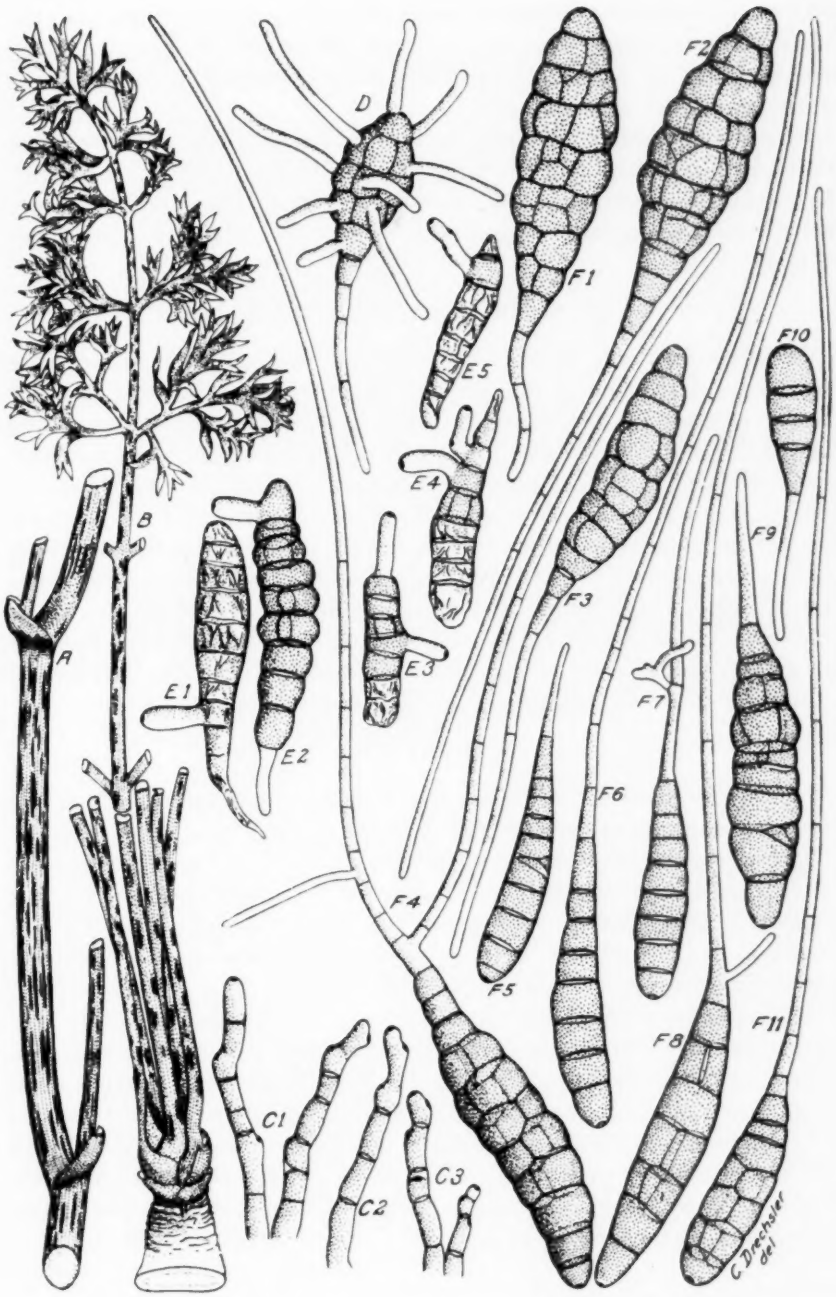


FIG. 2. A. Stem of a mature carrot plant, showing dark longitudinal lesions. × 1. B. Petioles and portion of blade of carrot leaf, showing discolored lesions of blight. × 1. C. Sporophores, showing variation in size and dark scars marking points of attachment of spores. × 350. D. Spore germinating by 9 germ tubes. × 350. E. 1–5. Spores more or less collapsed as result of proliferation of sporophoric processes × 350. F. 1–11 Spores showing characteristic terminal prolongations variable in length, usually septate; and sometimes branching. × 350.

with two longitudinal septa in some of the transverse segments, the septa both transverse and longitudinal associated with constrictions; measuring 10–22 × 34–51 μ, the primary spores usually exceeding those of the second or higher order.

Habitat: Found on roots of *Daucus carota*, in Massachusetts, New York, Pennsylvania, and Washington, D. C., causing a moderately destructive storage decay; also as result of inoculation on foliage and stems, where its attack results in conspicuous spotting and in death of leaves.

DISTRIBUTION OF THE DISEASE

Observations made during the three seasons that have passed since the disease first came to the writers' attention would indicate that the trouble is generally distributed throughout the carrot storage area of the Eastern United States. Dr. J. I. Lauritzen found the disease on carrots obtained from the Washington market, in April, 1919, approximately the same time that it was found by one of the writers on Long Island. During the seasons of 1919, 1920, and 1921 diseased material has been collected at Peconic, Orient Point, Southold, and Mineola, New York, and at Danvers, South Peabody, Arlington, and Framingham, Massachusetts. In March, 1921, the Pittsburg office of the Bureau of Markets Inspection Service sent in characteristic material that was taken from shipments said to have originated in Pennsylvania.

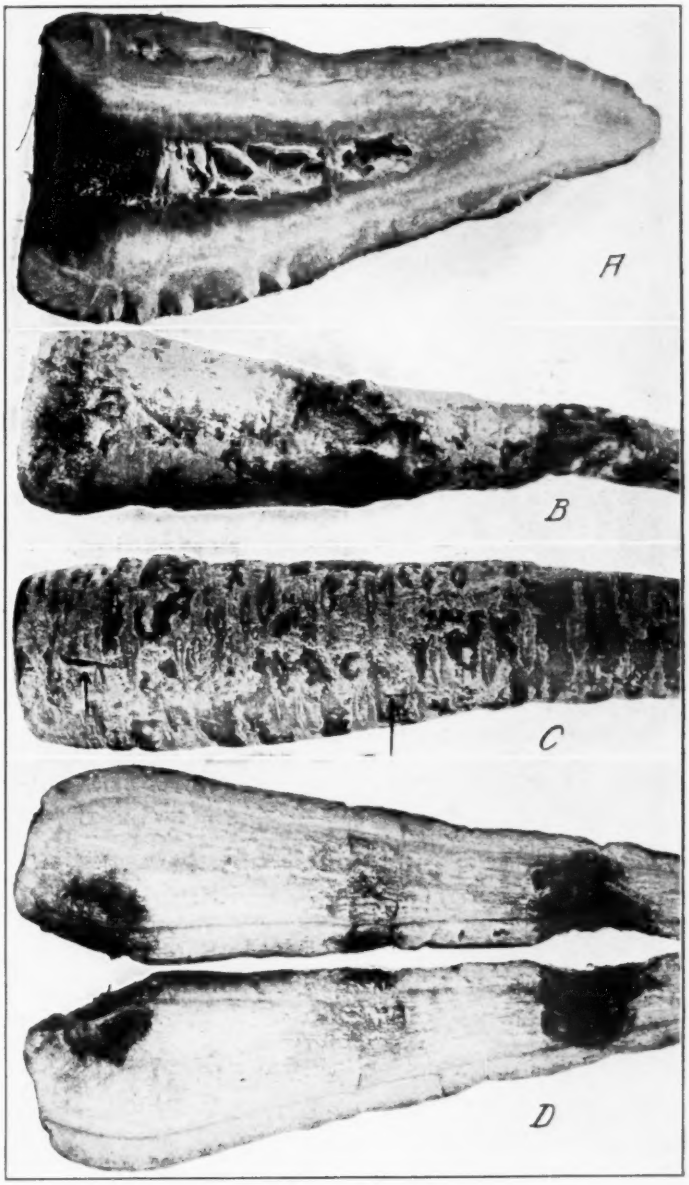
SUMMARY.

1. The "black rot" of carrots, a disease which attacks the roots during storage, is caused by *Alternaria radicina* n. sp.

2. Inoculation experiments show that under very favorable weather conditions this fungus may infect the foliage during growth, causing a spotting accompanied by wilting of the affected leaves. This diseased condition has not been found to occur naturally in any of the localities where the "black rot" of the roots developed.

3. The appearance of this disease on the foliage when it occurs as a result of artificial infection is similar to that produced by *Macrosporium carotae*, a distinct species and obligate parasite producing in nature a widely distributed foliage blight of actively growing carrot plants.

4. *Alternaria radicina* may perhaps best be regarded as a facultative parasite of undoubted vigor affecting mature tissues, particularly those of the more or less bruised or wounded roots while being harvested or undergoing storage.



BLACK ROT OF CARROTS

A. Longitudinal section of a carrot, showing black rot extending into the core of the root.

B. Three decayed spots resulting from inoculations with *Alternaria radicina*.

C. One of the carrots which were held as controls, showing two incisions which have healed over.

D. Longitudinal median section of the inoculated carrot shown in figure B.

UNIV OF MICH.

ISARIA ROT OF TOMATO FRUITS

F. J. Pritchard and W. S. Porte

With Plate XII and One Figure in the Text

INTRODUCTION

A new rot of tomato fruits has occurred in the vicinity of Washington, D. C., during the years 1919, 1920 and 1921. Although nothing further is known regarding its distribution, it would seem from its readiness in attacking tomato fruits to be capable of causing considerable damage. As no reference to it has been found in the botanical literature its chief points of interest are published in this paper.

DESCRIPTION OF INFECTED FRUITS.

Fruits affected by this rot are usually partly covered by a white cottony surface growth (Pl. XII fig. 7) that later becomes pink or pale orange and granular (Pl., XII, fig. 11). Sometimes the surface filaments are quite coarse (Pl., XII, figs. 9, 10) and occasionally greenish yellow in color, but in a dry atmosphere they may be inconspicuous or even absent (Pl., XII, figs. 1 2, 4–5). Although the quantity of surface growth varies with the humidity of the atmosphere, the types shown in Pl., XII, figs. 7, 9, 10 and 11 are quite characteristic of this rot.

CAUSE OF THE ROT.

This rot is caused by a fungus belonging to the genus Isaria. Like most species of this genus, it is relatively small and produces very small spores. Although it has been grown on various kinds of culture media and in a wide range of temperatures, it has not developed its perfect stage. It is therefore placed in the group of imperfect fungi.

PREVALENCE OF THE ROT IN THE FIELD AND IN THE GREENHOUSE.

This rot was first observed on field-grown tomato fruits and has since been found occasionally in the field at the Arlington Experimental Farm. It may be more common in this same area than these observations would seem to indicate, however, for it frequently develops in the interior of the fruits without much disintegration of the tissues and usually appears late upon the surface and may therefore be easily overlooked. It has been found frequently in the experimental greenhouses at Arlington, Virginia, and in Washington, D. C.

DESCRIPTION OF THE FUNGUS.

Isaria clonostachoides, n. sp.

Stroma composed of hyaline agglutinated hyphae (Pl. XII, figs. 13, 14) which become free toward the apex of the fascicle and bear spores at their tips, cylindrical below and conical above, 2–5 mm. high; conidiophores septate, repeatedly divided into whorls of 2 to 4 branches or subulate branchlets; conidia sometimes grouped in heads of the Acrostalagmus type but more commonly united into dense angular spikes, at first hyaline but later usually pink or pale orange in mass, 5–8.5 μ long by 3.2 μ broad,

Parasitic on tomato fruits in the vicinity of Arlington, Virginia, and Washington, D. C.

PENETRATION OF THE FRUITS.

Although *Isaria clonostachoides* infects tomato fruits a little more readily through punctures (Pl. XII, figs. 4, 5, 6) than through an unbroken epidermis (Pl., XII, figs 1, 2, 3) it is not dependent on wounds for entrance. It infects both green and ripe fruits (Pl. XII, figs. 7 and 11 respectively) and grows through all the tissues.

Thorough penetration of a green fruit is shown in (Pl. XII, fig. 8) in which the white masses of mycelium may be seen in the seed cavities, It has also spread through the central part, or core, and has even infected the seed, although the infected seed are not visible in the photograph.

CHARACTER OF THE ROT.

The tissues of tomato fruits infected by *Isaria clonostachoides* remain rather firm especially if green. Such an infected fruit as shown in plate XII, figure 8, for instance, seems quite tough when cut or squeezed. The rot causes very little odor and what little is produced is not unpleasant.

EFFECT OF INOCULATING TOMATO FRUITS.

One hundred green and one hundred ripe tomato fruits, half of which were pricked and half unpricked, were inoculated with *Isaria clonostachoides* in six series of experiments and kept in moist chambers at 24° to 25° C. The air in the chambers was kept moist by spraying the fruits with distilled water whenever their surfaces began to dry. The percentage of infections obtained on pricked green fruit was 60; on unpricked green fruit 40; on pricked ripe fruit 90; and on unpricked ripe fruit 50. An equal number of control fruits remained free from infection.

Two sets of inoculation experiments were made on fruits grown in the greenhouse. Both green and ripe fruits some of which were pricked and some unpricked were inoculated with a pure culture of this fungus

and covered at the point of inoculation with a small piece of wet cotton. Seventy-five fruits were thus inoculated and as many more were used as checks. Due probably to the drying of the cotton, none of the unpricked fruits showed any symptoms of the rot. About 50 per cent. of the pricked green fruits became infected but showed little surface growth while 60 per cent. of the ripe fruits developed the characteristic symptoms of the rot including the growth of mycelium on the surface.

Two hundred small green to large green tomato fruits were inoculated with *Isaria clonostachoides* and placed in a moist atmosphere in constant temperature chambers ranging from 0° to 40° C. The unpricked as well as the pricked fruits became infected but the ripening fruits and small green fruits were more readily infected and developed more rot than the large green fruits. Fully 70 per cent. of the fruits became infected in the chambers kept at about 29° C.

The seed of tomatoes infected by this fungus frequently become brown to dark brown in color and when transferred under aseptic conditions to sterile plates of agar-agar often become covered with a pure culture of the fungus.

EFFECT OF INOCULATING TOMATO PLANTS.

Twenty young tomato plants were inoculated in the roots and 20 were inoculated in the stems with *Isaria clonostachoides* and kept in a moist chamber 48 to 60 hours but no infections developed on the roots and only a few minute brown spots appeared on the stems and these made no further development. Millions of spores sprayed on the leaves of tomato plants growing in a relatively moist greenhouse caused no infections. This fungus would therefore seem to have very little parasitic action on the tomato plant.

GROWTH OF ARTIFICIAL CULTURE MEDIA

Isaria clonostachoides grows fairly rapidly on glucose agar, potato agar, potato plugs, lima bean agar, oatmeal agar, beef agar, and string bean agar but very slowly on corn meal agar. It imparts a greenish yellow color to oatmeal agar but produces no such change in any of the other media mentioned.

A typical 14-day old colony grown on string bean agar is shown in plate XII, figure 12. Erect filaments similar to those in the center of the colony usually appear on the entire surface when it becomes older. On a somewhat drier culture medium, as in an older plate; on the surface of tomato fruits which have become rather tough and dry from the action of the fungus; and on cotton and sweet clover stems the erect spore-bearing fascicles are so dense that the individual filaments composing them cannot usually be traced. Under these conditions the fruiting synnema is larger and denser than those shown in plate XII,

figures 12 and 14 but bears the same type of conidiophores on its apical and lateral surfaces.

The colonies are at first white but usually become pink or pale orange during spore production.

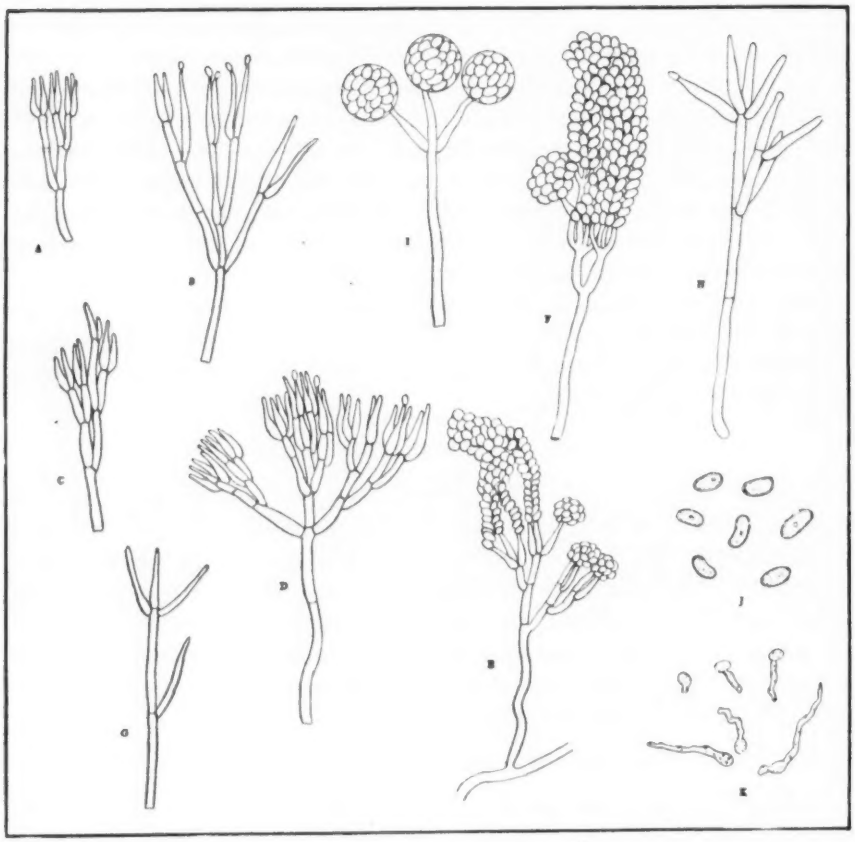


FIG. 1. Drawings of *Isaria clonostachoides*, n. sp. × 400, J × 880; A–D, Conidiophores of the compact type; E–F, Parts of conidiophores showing the structure of the conidial spikes; G–H, Conidiophores of the open, sparingly branched type; I, An open type of conidiophore bearing globular masses of conidia surrounded by a film of mucus; J, Conidia highly magnified; K, Germinating conidia.

RELATION OF TEMPERATURE TO INFECTION

The optimum and limiting temperatures for growth and infection by this fungus are recorded in table 1.

TABLE I

Influence of temperature on growth and infection by Isaria clonostachoides

Temperature relations	Temperatures degrees C[1]		
	Minimum	Optimum	Maximum
Growth on culture media.....	7	29	36
Infection of tomato fruits.....	14	29	32
Germination of spores.....	7	31.5	36

The optimum temperature is apparently the same for growth on artificial culture media as for infection of tomato fruits. The maximum and minimum temperatures for growth on culture media, however, are higher and lower respectively than for infection.

MORPHOLOGY OF THE FUNGUS

The hyphae of *Isaria clonostachoides* are grouped in bundles which grow more or less horizontally but become erect toward the tips causing a coarse filamentous appearance (Pl. XII, figs. 12, 13, 14). The bundles are cylindrical for the greater part of their length but, owing to the gradual separation and divergence of the ends of the hyphae, especially toward the apices, the tips taper to a point and not infrequently look to the unaided eye like repeatedly split hairs (edge of colony Pl. XII, fig. 14). When the tips of the bundles produce conidiophores and spores, however, they have an elongated conical appearance (Pl. XII, figs. 13, 14).

There are two types of conidiophores,—one dense or compact, and the other open, stiff, and more sparingly branched. In the dense type (Figs. 1 A, 1B, 1C,) the branches and branchlets are very narrowly separated and the conidia, one row from each branchlet, cohere laterally, forming a dense, angular spike (Figs. 1E, 1F) like those of the genus Clonostachys. A conidiophore of this type often bears several spikes, one from each terminal whorl or dense group of whorls of branchlets. In the other type of conidiophore (Figs. G1, 1H, 1I,) in which the branchlets are fewer in number and more widely separated, the conidia form singly on the ends of the branchlets as in the more dense type but usually cohere in globular aggregations surrounded by a film of mucus. This type of conidiophore does not seem to pass over into the more dense type although occasionally a few globular masses of conidia are found on the dense type (Figs. 1E, 1F).

The conidia on the two types of conidiophores are alike in size, shape, and other appearances (Figs. 1J, 1K). They are oval to curved in form and not infrequently somewhat blunt at one end, usually being rounded a little more at one corner than at the other. When produced on the more compact type of conidiophore they come into lateral contact with other conidia from the same whorl of branchlets and are carried

[1] These temperatures are only approximately correct as there was a difference of 3 or 4 degrees between some of the adjoining chambers.

outward in mass by the successive production of conidia below them, giving rise to a spike. When a branchlet is somewhat separated from the other branchlets of a whorl, (Figs. 1E, and 1F,) its conidia do not make this lateral contact with conidia from another branchlet and therefore form a globular mass instead of a spike. Apparently this is the only reason that the conidia on the compact conidiophores form spikes while those on the open less branched conidiophores form heads of the Acrostalagmus type. To form either spikes or heads however the conidia must possess an adhesive surface.

It is apparent from the foregoing description of this fungus that it is similar in some respects to Verticillium, Acrostalagmus, and Clonostachys. Those who place very little emphasis on the genetic significance of the synnema may regard it as one of these genera, especially Clonostachys. In fact, in the absence of the perfect stage, its genetic relationship is questionable. However, as the synnema is used as a family character in the current systems of classification and serves to separate the Moniliaceae from the Stilbaceae, this fungus would seem to belong to the genus Isaria of the latter group. As it does not fit the description of any of the species of Isaria already described it has been designated, at least tentatively as *Isaria clonostachoides*.[1]

SUMMARY

A new rot of tomato fruits caused by *Isaria clonostachoides*, n. sp. has been observed quite frequently in the vicinity of Washington, D. C., during the years 1919, 1920 and 1921. As the fungus produces innumerable spores and infects both green and ripe fruits readily, it would seem capable of causing considerable damage.

DESCRIPTION OF PLATE XII

Isaria rot of tomato fruits and appearance of the colonies on artificial culture media.

FIGS. 1–3. Fruits infected through an uninjured epidermis.

FIGS. 4–6. Fruits infected through needle punctures.

FIG. 7. Infected green fruit showing a white cottony surface growth.

FIG. 8. Green fruit showing white masses of the fungus in the seed cavities and core.

FIGS. 9–10. Fruits showing bundles, or fascicles, of hyphae on the surface.

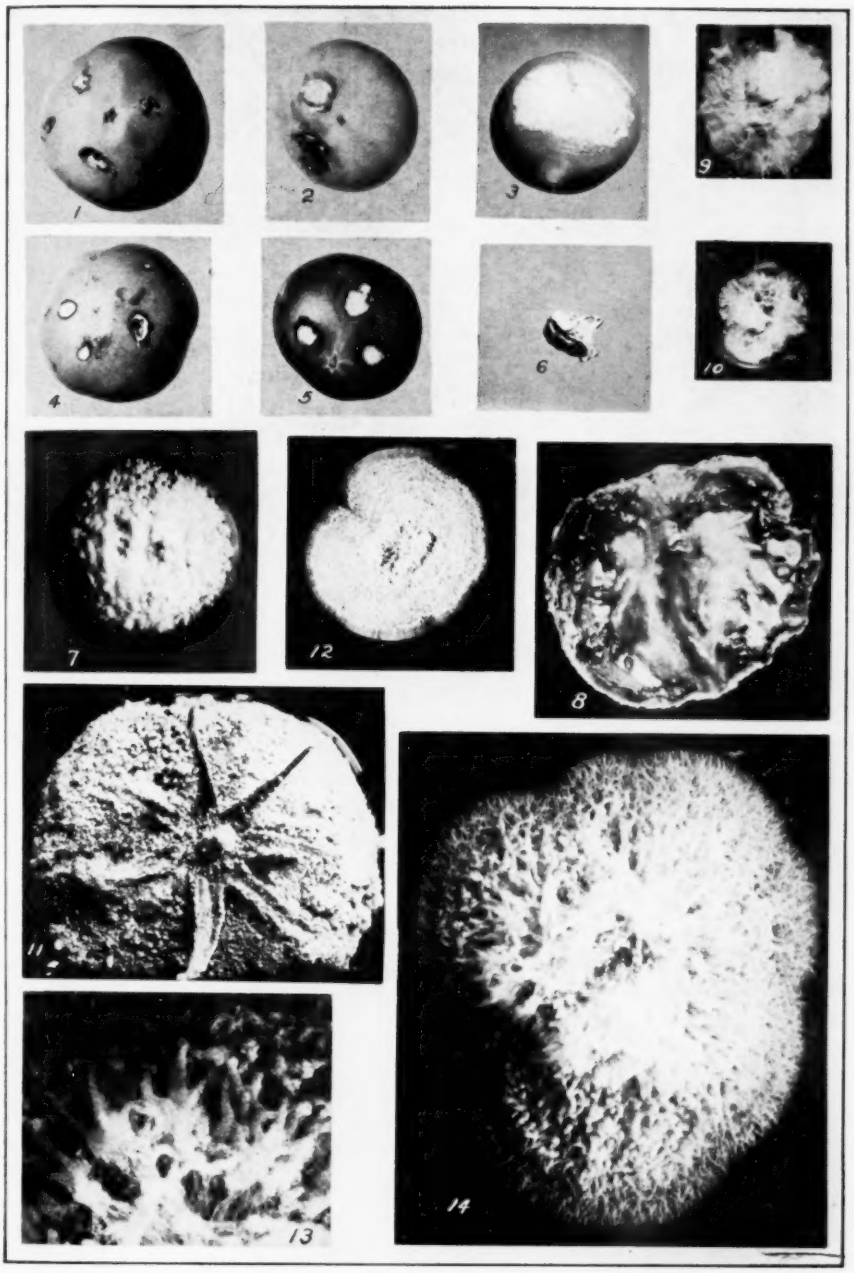
FIG. 11. A ripe tomato fruit covered by a pink or pale orange granular growth of the fungus.

FIG. 12. A typical 14-day old colony on string bean agar.

FIG. 13. Stromata highly magnified. × 25¼.

FIG. 14. Colony of the fungus showing fascicles and stromata. × 6¼.

[1] *Isaria filamentosa* Sacc. Mich. I, p. 132, F. ital. T 840 has been found growing on putrid stems of Solanum but the lateral diameter of its spores varies from 2.5 to 3.5 μ while that of *Isaria clonostachoides* varies very little from 3.2 μ. Moreover, *Isaria filamentosa* is white and does not form spore-heads or spore-ears.



ISARIA ROT OF TOMATO FRUIT

UNIV. OF MICH.

EFFECT OF DELAYED PLANTING ON GERMINATION OF SEED WHEAT TREATED WITH FORMALIN[1]

HARRY BRAUN

WITH PLATE XIII AND THREE FIGURES IN THE TEXT

It is often necessary to hold formalin-treated seeds for several days or a week, when immediate sowing after treatment is prevented by heavy rains and unworkable ground. Numerous cases of severe injury to germination, noted among others by Coons[2], have resulted from storage of seed wheat treated by the concentrated formalin dry method or even by the sprinkling or wet method. The present paper is a report of a small part only of a long series of experiments made to determine the effect of delayed planting, on the germination of seed wheat treated with formalin by the ordinary method and by the presoak method recently outlined by the writer[3].

EXPERIMENTAL METHODS

In December, 1921, five standard varieties of wheat were used: Marquis, Fultz, Turkey, Purple Straw, and Fulcaster. One set of seeds of each variety, in quart lots, was dipped for half an hour in a formaldehyde solution of 1 part commercial formalin to 320 parts of water, drained and covered one hour. Another set was treated in the same way, except that the seeds were first soaked in water 10 minutes, drained and covered five and a half hours to permit absorption of the water vapor by the seeds, before receiving the formaldehyde treatment. All seeds were then spread out to dry over night and part of the next day, in a layer about an inch thick, with occasional stirring for aeration. At the end of 24 hours 300 seeds of each variety were planted in the greenhouse in triplicate pots of 100 seeds each, with triplicate pots of untreated checks. The remainder of the treated seeds was placed in bags and kept a week in the laboratory (room temperature averaging 23° C.) then 300 seeds of each variety were counted out as before and planted in

[1] The author wishes to acknowledge his indebtedness to Dr. Erwin F. Smith for criticism and advice throughout this investigation.

[2] Coons, G. H. The Use of Formaldehyde to Control Cereal Smuts. *In* Mich. Agr. Exp. Sta. Quart. Bul., v. I, no. 1, p. 11–14. 1918.

[3] BRAUN, HARRY. Presoak Method of Seed Treatment: A Means of Preventing Seed Injury due to Chemical Disinfectants, and of Increasing Germicidal Efficiency *In* Jour. Agr. Res. **19:** 363-392. 1920.

the greenhouse in the same manner as those planted one day after treatment and with as many untreated checks.

Counts of germination of each planted set were made on the seventh, ninth and tenth days after planting.

On its completion the experiment was repeated (January, 1922) using the same procedure throughout. The germination percentages for the December and January plantings are charted in figures 1 and 2, and correspond closely to previous experiments in which these and other varieties were used.

DISCUSSION

The different appearance of the seedlings of the delayed January plantings, where 1, 2 are the controls, 3, 4 the ordinary formalin treatment, and 5, 6 the presoak formalin treatment, is shown for 4 of the 5 varieties on plate XIII.

A comparison of the data for the checks (A, AA) and the formalin-treated[1] seeds, planted one day (B) or one week after treatment (BB), shows in all cases definite and considerable injury to germination due to the treatment. Delay in germination is striking in that only *one-third to one-half* of the seedlings that developed from treated seeds appeared by the seventh day (solid bar), whereas the *majority* of the untreated seeds had germinated by this time. In Marquis and Fulcaster (first experiment) the final germination of formalin-treated seeds kept one week show an increase of 4 to 8 per cent over formalin-treated seeds kept one day, though marked retardation is evident in Fulcaster (solid bar). In all other cases there is retardation and a decreased germination of 3 to 22 per cent in formalin-treated seeds after a week's storage, as compared with those held one day. Averages of all varieties (lowest graphs) indicate clearly the general retardation and marked cumulative injury caused by storage of the formalin-treated seeds.

A comparison of the data for presoaked formalin-treated seeds, planted one day (C) or one week after treatment (CC), with corresponding checks (A, AA), and with formalin-treated seeds (B, BB), gives for the former: (1) in all cases, better germination than ordinary formalin-treated seeds; (2) germination equal to or better than that of corresponding checks, in all cases, except three where a decrease of 1 to 4 per cent as compared with the checks is not beyond the limits of experimental error; (3) marked stimulation of germination, since most of the seedlings appeared before the 7th day (solid bar). The averages

[1] The term "formalin-treated" will be used throughout to denote seeds dipped in formalin 1:320 half an hour, then drained and covered one hour; "presoaked formalin-treated" to denote seeds treated in the same manner but preceded by a ten-minute dip in water and a 5½ hour water-vapor absorption period.

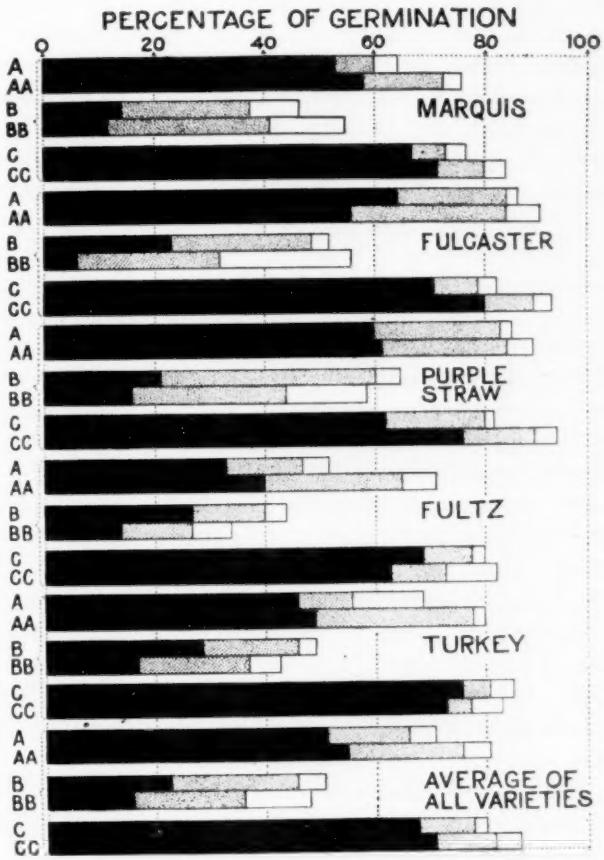


FIG. 1. Comparison of common *vs.* pre-soak formalin treatment of seed wheat and effect of immediate planting *vs.* holding treated seed one week before planting. Germinations on 7th day after planting, *solid bar;* 9th day, *shaded bar;* 10th day, *open bar.*

A—Check, untreated. Planted Dec. 3.

AA—Check, untreated. Planted Dec. 9.

B—Seeds soaked in CH_2O, 1:320 half-hour, (Dec. 2), drained, covered one hour, dried overnight in one-inch layer, planted Dec. 3.

BB—Same set as B, except that seeds were kept in bags one week and planted Dec. 9.

C—Seeds soaked in water ten minutes (Dec. 2), drained, covered 5½ hours, then treated with CH_2O as detailed in B, dried overnight in one-inch layer and planted Dec. 3.

CC—Same set as C, except that seeds were kept in bags one week and planted Dec. 9.

for all varieties indicate a distinct gain by use of the presoak method whether the seeds were held one day or one week before planting.

The constant higher germination of checks (see averages) in the plantings of December 9 (AA) and of January 4 (A), as compared with those of December 2 (A) and January 11 (AA), was found to be correlated with variations in amount of sunshine, which was more abundant during the germinating periods of these plantings than during the corresponding periods of the other plantings. Other factors, soil, watering and depth of planting, were constant and under control. Prevalence of sunlight or cloudiness may be expected to influence germination, by affecting soil temperature. Since, however, all seeds of a planted set, whether treated or untreated, are influenced equally by a factor of this nature, this factor may be stabilized and the data for the various plantings co-ordinated by transposing absolute to relative germination; *i. e.*, by considering final germinations of controls as 100 per cent and calculating germinations of treated seeds in reference to this norm. A clearer picture of the proportional effects of treatments, relative to a normal germination, may thus be obtained. Data thus calculated from averages in all plantings is charted in figure 3.

Figure 3 shows clearly: (1) delay and decrease in germination of formalin-treated seeds dried and planted a day after treatment (B); (2) accentuated injury to seeds similarly treated and kept a week before planting (BB); (3) no appreciable injury and some stimulation in presoaked formalin-treated seeds dried and planted a day after treatment (C) also evident throughout experiments reported in a previous paper[1]; (4) for presoaked formalin-treated seeds kept a week (CC), a slight decrease in germination as compared with treated seeds kept only a day but no appreciable injury as compared with checks, and germinating nearly twice as well as non-presoaked formalin-treated seeds kept a week.

On the whole it may be concluded that, whereas cumulative injury is apparent in formalin-treated wheat seeds held a week before planting, no appreciable injury is shown after a week's storage by seeds treated with formalin in the same way, but preceded by a ten-minute dip in water and a 5-½ hour water-vapor absorption period.

Full discussion of the causes involved is reserved for a later paper, but the following points may be briefly indicated. The well-known hardening effect of formalin, in this case on the pericarp, was considered by McAlpine[2] and G. P. Darnell–Smith and Carne[3] as a contributing cause

[1] Braun, Harry. l. c.

[2] McAlpine, D. Effect of formalin and bluestone on the germination of seed wheat. *In* Agr. Gaz. N. S. Wales, 17: 423–439. 1906.

[3] Darnell-Smith, G. P., and Carne, W. M. The effect of formalin on the germination of plants. *In* 3d Rpt. Govt. Bur. Microbiol. (N. S. Wales) 1912, p. 178–180. 1914.

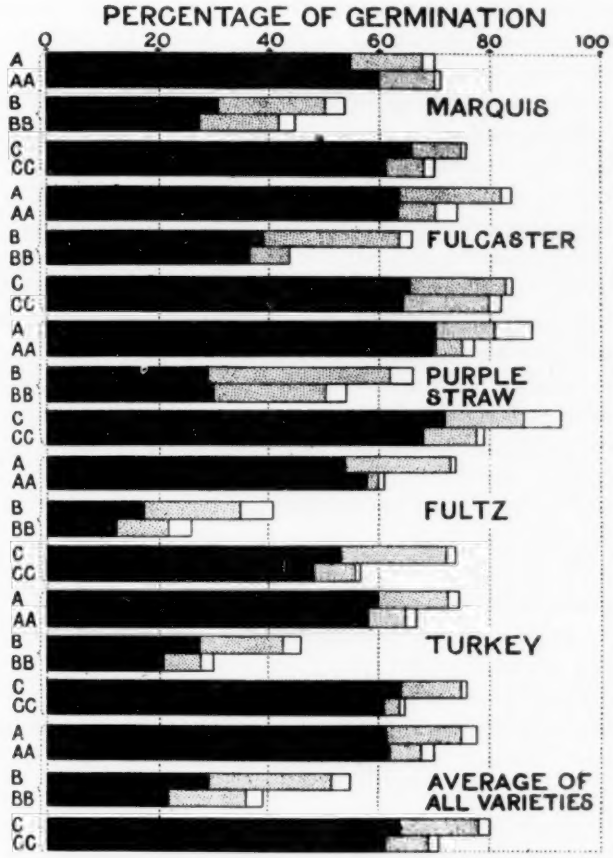


FIG. 2. Result of January treatments and plantings. Same terminology as in Fig. 1. Treated January 4: A, B, C planted January 5; AA, BB, CC planted January 11.

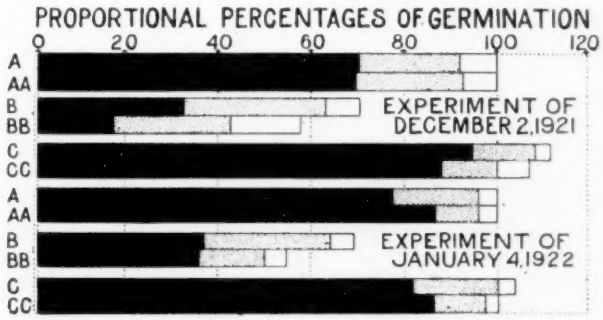


FIG. 3. Data of figures 1 and 2 but recalculated, as explained in the text, the checks being taken as 100 per cent

to cumulative storage injury after formalin treatment, in that a hardened pericarp prevents the primary root from pushing through or delays it. It is evident that the absorption of water-vapor by seeds previous to formalin treatment, tends to soften the tissue and counterbalance this hardening effect, and also tends to dilute the full-strength formalin absorbed by the pericarp and consequently to decrease its hardening and killing power.

Another possible cause of cumulative storage injury is the persistence of paraformaldehyde on the surface of treated seeds, suggested by G. P. Darnell-Smith and Carne[1], Coons[2] and Miss Hurd[3], who obtained typical formaldehyde reactions on dry-stored, formalin-treated seed wheat with Tollen's reagent (silver nitrate–sodium hydroxide–ammonia). Through absorption during the treatment period, the formaldehyde is probably also persistent, either in the polymer form or in a highly concentrated solution, within the pericarp tissues of the stored seeds as well as on the surface.

Tests with Tollen's reagent[4] on formalin-treated seeds dried and kept one week, and on presoaked formalin-treated seeds dried and kept one week, showed for the latter a formaldehyde reaction approximately one-fourth as intense as the former (See test tubes Pl. XIII, 1A). Similar tests made one day after treatment and drying showed a formaldehyfe reaction half as intense for presoaked formalin-treated seeds as for ordinary formalin-treated seeds (Pl. XIII, 1B).

These differences in amount of persistent formaldehyde (or the polymer, since Tollen's test does not distinguish between the two) indicate that less formaldehyde persists on presoaked formalin-treated seeds, through (1) greater evaporation of formaldehyde from the increased surfaces of the swollen seeds during the aeration period (2) less tendency for the polymer to form on the surface during the subsequent storage period, in the presence of the moist tissues immediately beneath; and as a corollary to this, absorption of surface formaldehyde during the storage period and its dilution beyond the point of injury by the water previously absorbed by the seeds.

[1] Darnell-Smith, G. P., and Carne, W. M. l. c

[2] Coons, G. H. l. c.

[3] Hurd, A. M. Injury to seed wheat resulting from drying after disinfection with formaldehyde. *In* Jour. Agric. Res. 20: 209–244. 1920.

[4] Equal parts of 10 per cent aqueous solutions of silver nitrate and of sodium hydroxide are mixed together and the resulting precipitate dissolved by gradual addition of strong ammonia. On adding 1 c.c. of the clear liquid to a solution containing formaldehyde, the solution slowly turns to a deep brown, and a black precipitate is finally formed. The rate and depth of coloration, and the amount of precipitate indicate the relative amount of formaldehyde present.

SUMMARY

(1) The hardening effect of persistent formaldehyde or its polymer on the pericarp is counteracted in the presoak method by the softening of seed tissues through previous absorption of water-vapor.

(2) Formaldehyde or its polymer does not persist on presoaked formalin-treated seeds to the same degree as on formalin-treated seeds without presoaking, either through increased evaporation during the aeration period, or less tendency to polymerize in the presence of water in the pericarp tissues during the storage period, or through absorption and dilution in the presoaked seed tissues.

(3) Experiments herein reported indicate that presoaked formalin-treated seed wheat may be held several days or a week before planting, without appreciable injury to germination.

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DESCRIPTION OF PLATE XIII

PLATE XIII (Seedlings).—Effect of delayed planting on germination of seed wheat treated with formalin with and without presoaking; photographed ten days after planting. Experiment of January 4, 1922.

1, 2, controls, 100 seeds planted in each pot; 3, 4, seeds soaked in formalin 1:320 half hour, drained and covered one hour, dried overnight in one-inch layer, kept in bags one week, then planted, 100 seeds to each pot; 5, 6, seeds soaked in water 10 minutes, drained and covered 5½ hours, then treated with formalin as in 3, 4, dried overnight in one-inch layer, kept in bags one week, then planted, 100 seeds to each pot.

FIG. A. Turkey: 1, 2, controls, 67 per cent germination; 3, 4, formalin-treated, kept one week, 30 per cent germination; 5, 6, presoaked formalin-treated, kept one week, 65 per cent germination.

FIG. B. Purple Straw: 1, 2, controls, 77 per cent germination; 3, 4, formalin-treated, kept one week, 54 per cent germination; 5, 6, presoaked formalin-treated, kept one week, 79 per cent germination.

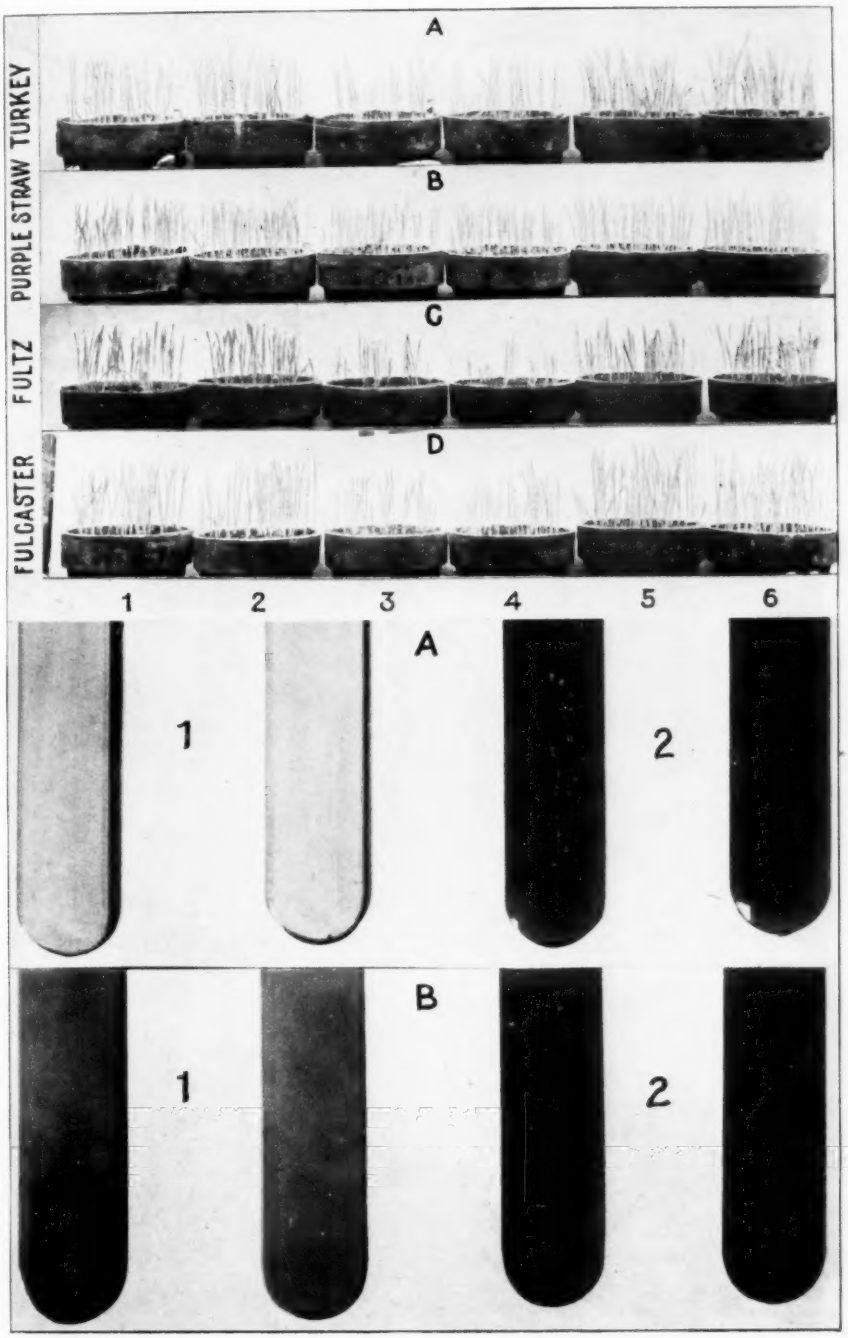
FIG. C. Fultz: 1, 2, controls, 61 per cent germination; 3, 4, formalin-treated, kept one week, 26 per cent germination; 5, 6, presoaked formalin-treated, kept one week, 58 per cent germination.

FIG. D. Fulcaster: 1, 2, controls, 74 per cent germination; 3, 4, formalin-treated, kept one week, 44 per cent germination; 5, 6, presoaked formalin-treated, kept one week, 82 per cent germination.

PLATE XIII (Tubes). —Relative persistence of formaldehyde on seed wheat treated with formalin, with and without presoaking.

FIG. A. Fifteen-gram samples from treated seeds, kept one week in bags, were shaken up with 25 c.c. of distilled water for 5 minutes; 10 c.c. samples pipetted into tubes, then one c.c. Tollen's reagent added to each in rapid succession; tubes photographed 10 minutes after addition of reagent. (1) Washings from presoaked formalin-treated seeds; (2) washings from formalin-treated seeds, without presoaking. The reaction of (2) is approximately 4 times as intense as that of (1), indicating the relative amounts of persistent formaldehyde after a week.

FIG. B. Similar tests made one day after treatment. (1) Washings from presoaked formalin-treated seeds; (2) washings from formalin-treated seeds, without presoaking. The reaction of (2) is approximately twice as intense as that of (1).



GERMINATION OF SEED WHEAT

UNIV. OF MICH.

NOTES ON THE ETIOLOGY AND SPECIFICITY OF THE POTATO TIP BURN PRODUCED BY EMPOASCA MALI LE BARON.[1]

JOHN R. EYER

WITH PLATE XIV AND ONE FIGURE IN THE TEXT

Recent investigations made by plant pathologists and entomologists to determine the etiology of potato tip burn have led to the conclusion that this disease is either of a physiological nature or caused by the feeding of the potato leafhopper (*Empoasca mali* LeB.). Lutman,[2] writing on the physiological aspect of the disease, has advanced the theory that the burning is due to excessive heat and sunshine during the hot portions of the growing season. He has also noted that the inordinate transpiration from the portions of the leaflets directly affected results in a wilting which he has attributed to the relation existing between the leaf transpiration and the water pores or hydathodes situated near the tip and along the marginal vein.

The association of a potato tip burn with the potato leafhopper was first observed by Ball[3] in 1918 who demonstrated a definite relation between the leafhopper and this disease. This burning differed from the physiological form by its initial appearance on the midrib and veinlets of the leaflets followed by the wilting of the interstitial tissue. Ball concluded that the explanation of the disease was to be found in "some specific transmitted by the insect" which when introduced into the circulation thru the veins caused the death of the tissue supplied by them.

To determine the nature and transmissibility of the "specific" injected into the potato by this species of leafhopper, inocula prepared by macerating the nymphal and adult stages of the insect in sterile water or 10–70 per cent alcohol, were introduced into the leaves of growing potato plants. A small hypodermic needle or capillary pipette was used and the inoculum was forced well into the tissue thru the midrib of the leaflet. Other plants were inoculated in a like manner with

[1] Contribution from the Department of Botany, The Pennsylvania State College. No. 36.

[2] Lutman, B. F. Tip burn of the potato and other plants. Vt. Agr. Exp. Sta. Bul. 214, 1919.

[3] Ball, E. D. The potato leafhopper and the hopperburn that it causes. Wisconsin Dept. of Agr., Bul. 23, 1919.

sterile water or alcohol to serve as checks. Inoculated plants were placed in the direct sunlight both in the greenhouse and in the field to contrast the effect produced under glass with that in the open and all were carefully screened from attack by leafhoppers.

In the field the plants evidenced a wilting and chlorosis of the tips of the leaflets eight days after inoculation and developed a characteristic tip burn in twenty days. In the greenhouse the progress of the disease was slower, the first symptoms appearing in thirteen days followed by the browning of the tips and lateral margins twenty-eight days after inoculation. The production of the disease artificially consumed more time than when it was naturally caused by the feeding of the leafhoppers in the field. In this case the initial symptoms were noticeable twenty-four hours after the insects began feeding and severe tip burn was produced in about four days by the nymphal stage of the leafhopper. (See Pl. XIV, fig. 2). Petiole inoculations usually resulted in chlorosis, browning, and death of the entire leaf. All check plants remained perfectly healthy, both in the greenhouse and in the field.

Inocula prepared from the leafhopper nymphs produced tip burn sooner and more readily than did those extracted from the adults. This was in confirmation with the results of Fenton[1] who demonstrated, by a series of cage experiments, that most of the foliage burning is caused by the nymphal stage of the insect.

Sterile water, or alcohol varying in strength from ten to seventy per cent, was used in preparing the inocula and the virulence of the extract was in direct proportion to the number of leafhoppers macerated in the solution and was in no way affected by the amount of alcohol.

Attempts to produce tip burn by pricking the inoculum into the interstitial leaf-membrane or by rubbing it on the healthy leaf were unsuccessful; the disease was only produced by direct inoculation of the leafhopper extract into the vascular system of the plant, either thru the midrib, veinlets, or stem. Mechanical injury of the midrib sometimes resulted in a browning similar to tip burn but this condition was restricted and did not spread beyond the group of cells injured.

To ascertain whether the causative principle of the disease existed in the injured tissue after infection by leafhoppers an alcoholic extract was made from leaves showing varying stages of hopperburn. This was then inoculated into the midribs of healthy leaflets and the disease was produced six weeks after inoculations; a somewhat longer period than in the case of the inoculum prepared directly from the leafhoppers. These symptoms compared closely with the disease produced by the leafhopper extract and were just as marked.

[1] Fenton, F. A. Progress report on the season's work on the production of potato tipburn. Jour. Econ. Ent., **4**: 71–79, 1921.

The specificity of the disease transmitted to the potato plant by *E. mali* was demonstrated by a series of comparative inoculations with inocula prepared from a number of sucking insects which normally feed on the potato plant. Extracts prepared from the potato aphis (*Macrosiphum solanifolii* Ashm.), the tarnished plant bug (*Lygus pratensis* Linn.), and the apple leafhopper (*Empoasca unicolor* Gill.), produced negative results. Inoculations of the false chinch-bug (*Nysius ericae* Schill.) caused chlorosis and death of the leaflets but this condition did not resemble tip burn.

Fig. 1. Tipburned potato plant sixteen days after inoculation with leafhopper extract. Exposed to the direct rays of the sun in the green house.

A relation between the amount of light and the progress of the disease was noted in all of these experiments. (See Pl. XIV, figs. 1, 2). The initial appearance and the development of the burning was much slower in plants grown in the greenhouse in winter than in those grown in the field during the summer months. (See Fig. 1). Cages of heavy cheese cloth which shaded the plants retarded the development of the disease. (See Pl. XIV, Fig. 1.) It was found possible however, to produce

tip burn in the absence of direct sunlight either thru the feeding of the leafhoppers or by inoculating the plants. In this case the development of the burning required four or five weeks and was superceded by an extensive chlorosis of the leaflets.

CONCLUSIONS

A tip burn of the potato plant is produced by the extract made from macerated leafhoppers of the species *Empoasca mali* LeB. and is transmissible by direct inoculation.

The active principle of this extract is most virulent in the nymphal stage of the leafhopper.

The "specific" of tipburn is present in diseased leaf-tissue after infection by the leafhopper and may be transmitted to healthy plants by re-inoculation.

This substance is specific and the disease has not been simulated by inoculation with extracts from or by the direct feeding of insects other than *E. mali*, or by mechanical injury.

Sunlight is an important factor in the progress of tipburn after its inception but the absence of sunlight does not prevent the disease.

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OBSERVATIONS ON FROST PROTECTION AND DROUTH SPOT OF APPLE

J. F. ADAMS

WITH ONE FIGURE IN THE TEXT

The frosts in Delaware during the latter part of March and the first part of April so seriously affected the apple yield, that approximately only a twelve per cent. crop for the state was harvested. However, the occurrence of one normal crop of apples during this exceptional season of 1921 has been of special interest in connection with observations on the prevalence of drouth spot.

A full crop of apples in a block of sixty-five acres of thirteen year old trees consisting of Staymans, Transparent, Ben Davis, Winesap and York Imperial was observed at the York Imperial Orchard, Seaford, Delaware. Through the kindness of Dr. W. Devitt, manager of this orchard, the following facts were secured concerning the conditions because of which this full set of fruit occurred.

The block of apple trees in this instance, was situated within one-hundred yards of a two hundred acre wood lot and extended beyond for about one-eighth mile. During the winter months the wood lot

TIPBURN OF POTATO LEAVES

Fig. 1. Tipburn produced in cages of heavy cheese cloth (minimum amount of sunshine) by the feeding of leafhopper nymphs. Photograph taken thirteen days after the leafhopper nymphs commenced feeding.

Fig. 2. Tipburn produced in the field under natural sunlight conditions by nymphs of *E. mali*. Photograph taken 9 days after the nymphs began feeding.

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had been cut over and the wood utilized for charcoal. Twenty furnaces were built on this cleared ground by placing the wood in piles measuring fourteen feet in diameter at the base and twelve feet in height. These piles of wood were then covered with about one foot of earth, thus completing the construction of the charcoal furnaces, which were burned until late in the spring. The above mentioned block of apple trees was situated southeast of the wood lot and incidentally in the same direction as the winds which prevailed during the late frost period.

Owing to this location, the blossoms on these trees were unquestionably protected from the freezing temperatures by the smudge which was produced from the burning furnaces. The remaining part of the orchard situated at one side of these protected trees was unsmudged and as a result most of the blossoms were destroyed, as likewise occurred in all other orchards throughout the state because of the existing low temperatures. However this occurrence was a coincident in so far as the resulting effects produced on the orchard, as the work on the wood lot was not conducted by the orchard company.

The failure of the trees to set fruit in the unsmudged part of the orchard indicates clearly the protection from the freezing temperatures brought about by the presence of the smudge. O'Gara (3) in connection with his work on protecting orchards from low temperatures states, "in several instances the orchards which had been smudged set a full crop, while in those that were similarly situated and not smudged the crop was entirely destroyed."

It was determined by O'Gara (3) in his work in the Pacific Northwest that the following temperatures were destructive to the apple trees: in bud 27° F., in blossom 29° F., and with setting fruit 30° F. These temperatures are approximately those of air in contact with the blossoms and fruit. The freezing temperature this spring in Delaware during the blossom period ranged from 25°–28° F. O'Gara found that a smudge was not as effective as fire to raise the temperature but can be depended upon to raise it a degree or two. A smudge is very protective in the morning before the sun comes up. It is intended only as a blanket to prevent the sun from warming up the blossoms too quickly where some slight freezing of the blossoms and the fruit has occurred during the night.

Fruit on the York Imperial trees showed a prevalence of drouth spot which disease is similar to symptoms described by various investigators as Yorkspot, Crinkle and Hollow Apple. The affected fruit showed large irregular surface depressions which when cut reveal pockets of corky tissue as shown in figure 1. The large depressions were often crescent shaped but small circular depressions were not uncommon resembling injury produced by hail stones. In all instances the de-

pressions were confined to the blush face of terminally attached fruits, but no more common to the blossom than the stem end. The normal skin over these depressions is usually a darker green. Some fruits are considerably malformed and observations during the season show a general retarded development of seriously affected fruit. Small apples that are severely affected often show over the depressions a dark brown discoloration of the skin. In such cases a gummy exudate is secreted similar to the bacterial exudation of fire-blight infection. Small droplets of the white exudation are common around the margin of the depressions

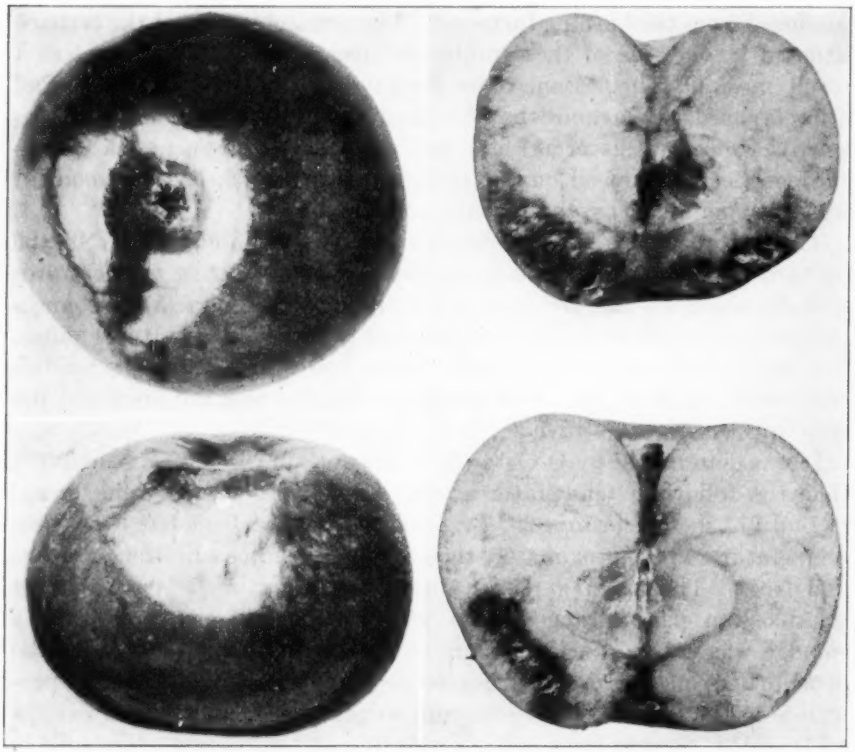

Fig. 1. APPLES AFFECTED WITH DROUTH SPOT.

but usually distributed over the surface as a thin sticky film. Such fruit hangs on but a short time and are the first to fall, usually by the middle of July under our conditions. The collapsed tissue under these depressions is light brown in appearance and often a pronounced shrinkage of the tissue occurs leaving large irregular air spaces. Affected apples that had remained undeveloped by the first part of August often showed symptoms of "glassiness" or "water core" in the pulp

adjacent to the collapsed tissue. Severely affected fruit showed evidence of such collapse that, in some instances, the black rot fungus had become established. Several diseased apples picked on the first of August were kept under temperature conditions of 65° F. After a month's time no apparent progress of the disease was observed. At the end of two months the apples showed considerable shrinkage and crinkling of the skin. The diseased areas were deeper and the skin considerably wrinkled.

The prevalence of the disease was estimated at five per cent. the first of August. A month later most of the affected fruits on the trees had fallen to such an extent, that the prevalence of the disease was reduced to one per cent. Only the large developed fruit with small depressions were found to hang on at this time.

Brooks and Fisher (1) state, "while it seems probable that Yorkspot is in part an effect of drouth, its occurrence is undoubtedly greatly influenced by sunlight and possibly by soil conditions and other agencies." Mix (2) considers drouth spot as occurring early in June and fresh stages may develop throughout the summer if the weather continues dry.

A long period of drouth occurred during the first half of the growing season. In this orchard the disease was further favored by a very light shallow surface soil and hard pan. The lack of moisture was also indicated by the short growth of crab-grass around the trees. Shallow planting, hard pan and crown gall infection are further important predisposing factors.

Considerable difference is found in the reaction of varieties to conditions of drouth. The York Imperial has been observed most seriously affected, and only a trace was found on Staymans. Mix (2) reports drouth spot in New York state on McIntosh, Northern Spy, Ben Davis, Esopus, Bellflower, Maiden Blush, Wolf River, Wealthy, Baldwin and Jonathan. Brooks and Fisher (1) report it particularly common on York Imperial apples and occurring also on the Gano and Esopus varieties.

AGRICULTURAL EXPERIMENT STATION,
UNIVERSITY OF DELAWARE.

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(2) MIX, A. J. Cork drought spot and related diseases of the apple. N. Y. Geneva Agr. Exp. Sta. Bull. 126: 473–522. 1916.

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SOME OBSERVATIONS ON ALFALFA GIRDLE

J. G. Brown and Frederick Gibson

With Plate XV

Among the diseases inflicting loss on the alfalfa growers of the Southwest is one whose cause is as yet unknown, although the symptoms were reported in a publication of the Arizona Experiment Station over twelve years ago. This disease is commonly referred to under the name of alfalfa girdle. It has become one of the important diseases of alfalfa in Arizona, occasionally spreading over entire fields. The past season was a very favorable one for the development of girdle in southern Arizona and the abundance of material within easy reach prompted the investigations (mainly the work of the junior author) that are briefly recorded in this preliminary paper.

Alfalfa girdle was first reported by Dr. W. B. McCallum[1], at that time physiologist and pathologist in the Arizona Experiment Station, in 1909, and the disease was attributed by him to a species of Phoma. Dr. McCallum made no cultures or inoculations, but based his opinion on the finding of numerous pycnidia on the diseased plants. His conclusion is not supported by the few investigators who have given some attention to the disease. Osborn[2] in 1911 reported a girdle on alfalfa which he ascribed to the activities of an insect, *Stictocephala sp.* Other suggestions expressed orally by botanists who have had an opportunity to observe the disease in the field have included as the cause the effect of standing irrigation water, leaf hoppers, gnawing insects, etc. According to reports farmers have even attributed the trouble to smoke from smelters The girdle has been found in most of the valleys of Arizona, in California and Colorado.

The first visible symptom of girdle formation is a slightly sunken band of light green color which widens and becomes gray-green. However, a slight enlargement can be located on the stem by using the finger tips before the shrinking of the diseased tissue occurs. As the disease progresses the girdled plants are easily located in the field, even from a distance of several rods, by the discoloration of the leaves and stem. The leaves are purplish at first, later turning yellow above, with more or less purple persisting on the under surface and at the petiolar end of the leaflet, or they may become red before turning yellow. The stem may become purpled or reddish green from the tip downward to the girdle, while the portion below the girdle remains normal in color.

[1] McCallum, W. B. Plant Physiology and Pathology. Ariz. Agr. Exp. Sta. Rep. 20:583. 1909.

[2] Osborn Herbert. Economic Importance of Stictocephala. Journ. Econ. Entomol. 4: 137–140. 1911.

The girdle is occasionally spiral in form, but usually it is a complete band of diseased tissue extending in a circle around the stem. The border is often slightly raised and dark colored, almost black, with gradual blending of color into normal green. Those girdles near the ground may have a thickened collar just above the shrunken band in which nematodes are sometimes found. Such thickened growths are also produced on the stem at a considerable distance from the soil line, in which case nematodes are absent. The tissue inside the dark margin varies from gray to dark brown. The epidermis always covers the shrunken part, which indicates that the injury is not due to the attack of a gnawing insect.

Another characteristic accompanying the girdle is the formation of incipient roots just above the shrunken area. This condition may exist within an inch of the tip of the stem in plants a foot or two in height. Evidently the stimulation of the tissues deeper than the epidermis and adjacent cortical cells is involved.

No girdle appeared in a certain small plot of alfalfa when it was young and tender, until about the first of August when the whole plot became so badly diseased that further cutting ceased. A few stems grew to the length of a foot or more, but they eventually became so badly diseased that they soon died. As many as eleven girdles were found on numerous single stems in the plot while one individual stem had sixteen. A large number of girdles is rare under field conditions, the average usually observed being one or two per stem, but three or four may be found. On one plant growing wild among weeds so that it made growth for a full season before being cut, four to six girdles were observed on lateral branches.

The junior author discovered girdles similar in appearance to those on alfalfa on several wild plants in the vicinity of the Experiment Station. The list of diseased specimens[1] now includes twelve species besides alfalfa: *Franseria tenuifolia, Euphorbia nutans, Verbesina encelioides, Tribulus terrestris, Melilotus officinalis, Cassia covesii, Bahia absinthifolia* var. *dealbata, Baileya multiradiata, Oxalis corniculata, Eriocarpum gracile, Psilostrophe cooperi* and *Melilotus indica.* Probably more plants bearing girdles of similar nature will be found, since those enumerated in this list were located within a few hours and on a comparatively small area. It remains to be seen whether all of the girdles are due to a common cause. One of the plants, *Oxalis corniculata,* showed just below a perfect girdle a scale insect (*Coccus hesperidum* Linn.[2]) on one

[1] Identified by Prof. J. J. Thornber.

[2] Identified by Prof. G. F. Ferris, Leland Stanford University.

side of the stem and a partial girdle on the opposite side. It is probable that the scale is connected with the disease as a carrier of the organism causing the girdle, if not otherwise related to the disease.

Histological preparations have been started but only a few are ready for examination. These show that both fungi and a bacterium are present and that the shrunken area of the girdle lies over a diseased region reaching inward to the cambium. The enlarged collar-like growth of tissue above the shrunken portion includes branches from the stele which perhaps are connected with the formation of incipient roots.

About fifty cultures have been made by sterilizing girdled portions of alfalfa stems and also those of a few other species, and placing the sterilized blocks of tissue on agar slants. From these cultures there have been isolated a species of Alternaria, a Fusarium and a bacterium whose nature has not yet been determined.

ARIZONA AGR. EXP. STA.
TUCSON, ARIZONA
JANUARY 12, 1922

DESCRIPTION OF PLATE XV

PL. GIRDLE DISEASE ON VARIOUS PLANTS

Fig. 1. Coccus hesperidum on stem of Oxalis corniculata. Note partial girdle on side of stem opposite scale and perfect girdle above.

Fig. 2. Stem of Oxalis corniculata showing scale illustrated in Fig. 1.

Fig. 3. Enlarged photograph of the alfalfa girdle and collar illustrated in Fig. 4.

Fig. 4. Stem of alfalfa with girdle and collar at base. The leaves were yellow at the top of the stem, purplish still farther down and green at the base.

Fig. 5. Alfalfa. a. Branching girdle; b. Ordinary type; c. Later stage than preceding girdle.

Fig. 6. a. Oxalis corniculata; b. Eriocarpum gracile; c. Franseria tenuifolia (Gaertneria tenuifolia); d. Melilotus indica; e. Melilotus officinalis; f. Cassia covesii; g. Bahia absinthifolia, var. dealbata; h. Baileya multiradiata; i. Euphorbia nutans; j. Verbesina encelioides; j. Tribulus terrestris.

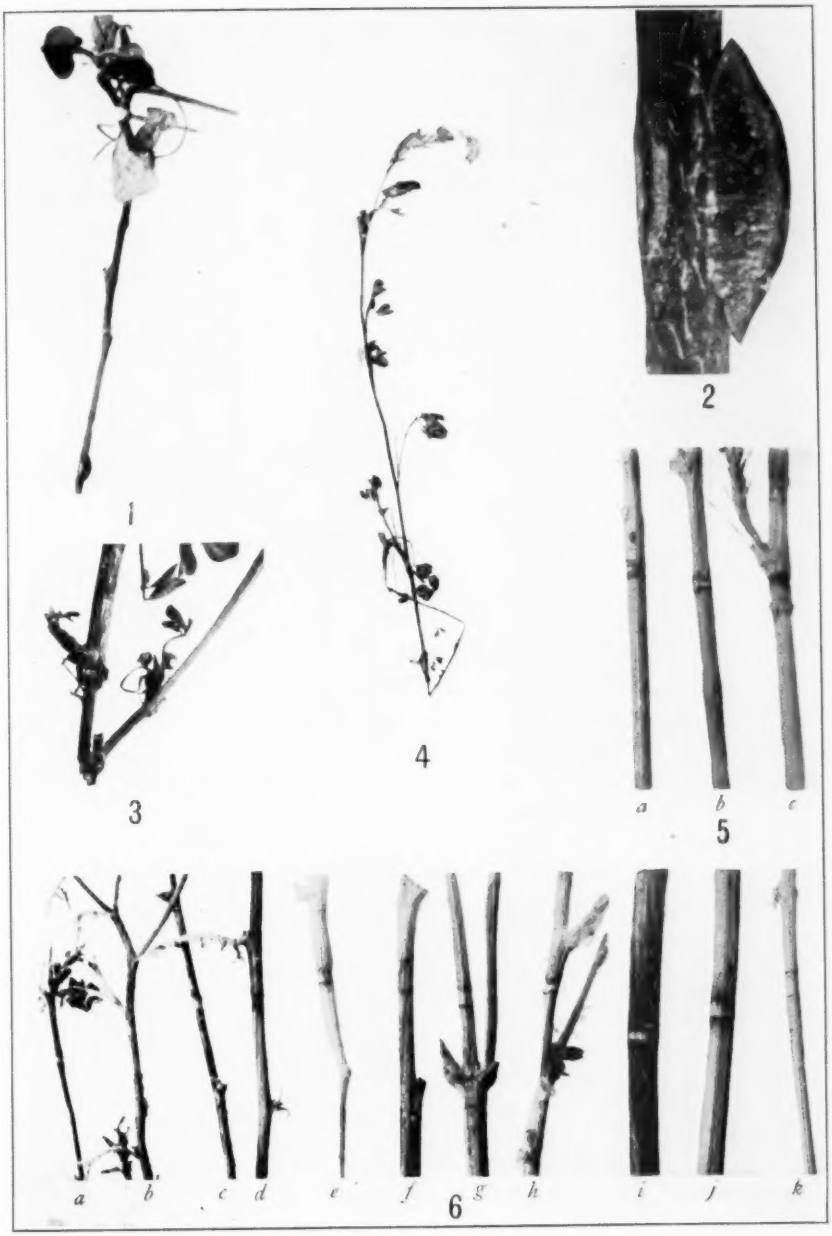
VARIETAL SUSCEPTIBILITY OF THE YELLOW BELLFLOWER APPLE TO CEDAR RUST[1]

E. F. HOPKINS

WITH ONE FIGURE IN THE TEXT

In the spring of 1921 specimens of apple twigs apparently affected with rust were referred to the writer by Professor H. A. Cardinell of this institution with the statement that the trees were severely affected

[1] Published by permission of the Director of the Agricultural Experiment Station, University of Missouri.



ALFALFA GIRDLE

UNIV. OF MICH.

by the trouble. Examination of the aecidia showed that a large number of them contained spores, the measurements of which compare very well with those given for *Gymnosporangium Juniperi-virginianae* Schw. Some of the twigs were sent to Dr. L. R. Hesler of the University of Tennessee and Dr. N. J. Giddings of the University of West Virginia who confirmed the writer's identification of the material. The accompanying figure shows some of the twigs which bear lesions of cedar rust. It was noticed in several instances that lesions occurring near a bud caused it to swell and start into activity as shown on the middle twig.

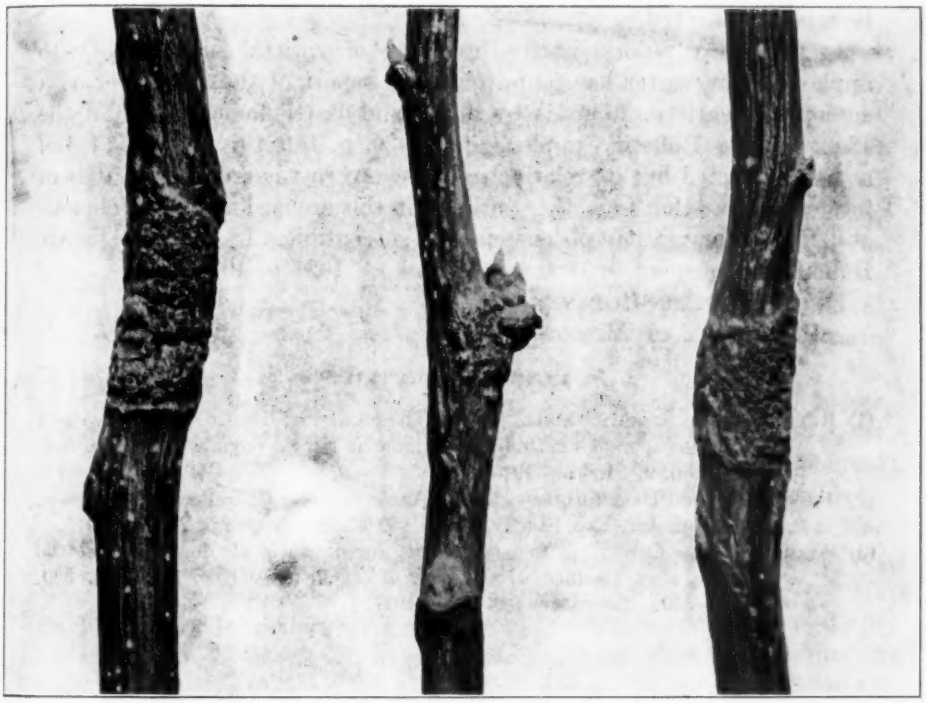


FIG. 1. CEDAR RUST LESIONS ON APPLE TWIGS

The diseased specimens came from a farm in Cole County, Missouri, and occurred in a large block of apple trees consisting of a number of varieties. It was observed by Mr. T. F. Lueker, County Agent, who visited this orchard later, that only one variety, the Bellflower, was affected with rust. He says "We looked the orchard over carefully yesterday and did not find a single case on any of the other varieties." Besides some seedling trees of unknown variety there were present in this orchard the following varieties: Bellflower, Early Harvest, Delicious, Winesap, Huntsman, Green Pippin and Jeniton. This list includes

both early and late apples which were planted in among the Bellflower trees.

In connection with the above observations two points are of interest first, the abundant occurrence of cedar rust on apple twigs and second, the marked susceptibility of the Bellflower variety. According to Reed and Crabill (1) in the variety Smith's Cider which is very susceptibile to rust the twigs are frequently seriously diseased. Jones and Bartholomew (2) report that young twigs may be attacked although little damage is caused on cultivated apples in Wisconsin. Weimer (3), states that in the case of susceptible varieties twigs of the current year's growth may be severely affected.

In the many reports in the literature of varietal susceptibility to apple rust the writer has found only one report of the Bellflower as a susceptible variety. This is by Jones and Bartholomew (2). In the Plant Disease Bulletin Supplement 9, 1920, p. 110, this variety is listed as being affected but its relative resistance to rust is not given. It is of interest to note that two other varieties in this orchard namely, Delicious and Early Harvest have been reported susceptible. (See Plant Disease Bulletin Supplement 9, 1920 p. 108 and 14, 1921 p. 40.)

DEPARTMENT OF BOTANY,
UNIVERSITY OF MISSOURI.

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(1) REED, HOWARD S. and CRABILL, C. H. The cedar rust disease of apples caused by Gymnosporangium Juniperi-virginianae Schw. Virginia Agr. Exp. Sta. Tech. Bul. 9. 106 p. 1915.

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PHYTOPATHOLOGICAL NOTES

Occurrence of Phloem necrosis in leafroll tubers. Phloem necrosis in stolons and tubers of plants affected with the leafroll disease has rarely been reported, however, observations recently made by the writer show its wide distribution even in these organs, and often a severity of symptoms more pronounced than those occurring in the lower aerial stem.

Plants of long leafroll lineage show evidence of necrosis in the stolon even before the new tubers have attained an appreciable size. The diseased groups are commonly found in the inner cycle. They show the same progressive lignification observed in the stem, and like in the latter the severity of necrosis depends on the age of the organ. Mature tubers are often borne on stolons, the phloem tissue of which is completely diseased; in the tuber itself, however. the advance of necrosis is slow, being confined primarily to the basal region, though occasionally diseased groups extend as far as to the terminal bud.

If leafroll tubers, which show only the beginning stages of necrosis, are dug up and examined again after the new plants have reached an appreciable size, it will be seen that necrosis of the phloem in the seedpiece has become greatly intensified and that the seedpieces from lateral and terminal eyes, which showed no necrosis before planting, will have it developed.

A number of experiments were conducted with whole and cut tubers to determine the relative development of necrosis in the seedpieces after the latter were planted. The tubers were cut into four parts, planted in six-inch pots, and plants and tubers examined after two months of growth. The tubers, at the time of planting, showed only slight necrosis in the basal region while the vascular tuber connection to the intercallery and terminal buds were altogether normal.

The results from these experiments only confirmed earlier observations in that necrosis developed only in vascular tuber tissue connecting to actively growing sprouts, the phloem tissue in the region of the dormant buds being normal. In case of single eye cuttings, necrosis would develop in every seedpiece, but there was a decided variation in the degree of necrosis, vigor of the individual eyes, and earliness of sprouting. There is no regularity in these variations, however, which would permit of showing distinct correlation of any of the factors; for, although the apical bud tends to be most vigorous and the basal one the weakest, the exceptions only tend to prove that vigor is a property of the individual eye, and this is depending on morphological and physiological factors, and is not necessarily affected by the position of the bud on the tuber.

Development of necrosis in the seedpiece is undoubtedly linked up with growth activities and movement of food initiated in the sprouting eye. There is an increase in vascular tissue, to accommodate the increased transfer of food substances, a condition not found in dormant buds. The relative severity of necrosis in stolons and tubers and the earliness of its development appears to be an index to the length of existence of the disease in a tuber line.—E. ARTSCHWAGER

Personals. Dr. Perley Spaulding, Editor-in-Chief of Phytopathology, left Washington April 4 for Europe, where he will spend the remainder of 1922, making investigations of the white pine blister rust. He will also represent the U. S. Department of Agriculture at the International Institute of Agriculture at Rome. Dr. L. L. Harter, U. S. Department of Agriculture, Washington, D. C., has been appointed by the Council as Acting Editor-in-Chief of Phytopathology during the remainder of the current year.

Dr. Arthur S. Rhoads, formerly Assistant in Forest Pathology of the U. S. Bureau of Plant Industry, and more recently of the Office of Cereal Investigations and the Office of Fruit Disease Investigations of the same bureau, has resigned to accept the position of pathologist at the Missouri State Fruit Experiment Station at Mountain Grove, Missouri.

Dr. R. D. Rands, formerly pathologist in the Office of Cereal Investigations, U. S. Department of Agriculture, and for three years under contract with the Dutch Government to conduct important investigations on the diseases of rubber and cinnamon trees in Java and Sumatra, arrived in Washington March 20.

F. J. Schneiderhan has been appointed assistant plant pathologist at the Virginia Agricultural Experiment Station for work on fruit diseases. He is stationed at Winchester in charge of the field laboratory at that place. The work includes a study of the development and control of apple scab, blister canker and other diseases.

Pacific Coast meeting of Phytopathology.—The Pacific Division of the American Phytopathological Society will meet in Salt Lake City, Utah, June 22–24, in conjunction with the summer session of the American Association for the Advancement of Science. It is hoped that any members of the parent society who are contemplating a trip to the Rocky Mountains or the Pacific Coast will arrange to be at Salt Lake City for this meeting. Those who wish to present papers at this meeting, please notify S. M. Zeller, Secretary-Treasurer, Pacific Division American Phytopathological Society, Oregon Agricultural College, Corvallis, Oregon.—S. M. ZELLER.

REPORT OF THE THIRTEENTH ANNUAL MEETING OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The thirteenth annual meeting of the Society was held in the Mining Building of the University of Toronto, Toronto, Canada, December 27–30, 1921, in conjunction with the American Association for the Advancement of Science and affiliated scientific societies. President Donald Reddick presided and about eighty-five members were present. The headquarters of the Society were at the King Edward Hotel.

There were ninety-seven papers on the regular program, abstracts of which were printed in the January number of Phytopathology. Advance separates of the abstracts were mailed to all members of the Society before the meeting.

There were three joint sessions with other societies. On Wednesday afternoon, December 28, occurred the annual meeting of Section G of the American Association for the Advancement of Science. At this meeting Dr. R. H. True, retiring Vice President of Section G, gave an address entitled The Physiological Significance of Calcium for Higher Green Plants. There was also a symposium on Utility of the Species Concept, C. F. Millspaugh speaking from the viewpoint of a systematist, G. H. Shull from the viewpoint of a geneticist, R. A. Harper from the viewpoint of a morphologist, G. B. Reed from the viewpoint of a bacteriologist and physiologist, and E. C. Stakman from the viewpoint of a pathologist. On Thursday afternoon, December twenty-nine, the American Phytopathological Society met with the Mycological Section of the Botanical Society of America for the reading of papers, half of the number being contributed by each society. On Saturday morning, December 31, a joint session was held with the American Association of Economic Entomologists for the consideration of Insects as Disseminators of Plant Diseases. Papers were presented by F. V. Rand on Results of Past Investigations, E. D. Ball on Systematic Relations of Carriers, L. Caesar on Control Problems, and M. W. Gardner on Urgent Problems of the Future. These four papers will appear in an early number of Phytopathology.

The annual dinner of the Society was held Thursday evening, December 29, in the beautiful dining hall of Wycliffe College and was attended by one hundred and ten pathologists and botanists.

The following officers were elected:

President, E. C. Stakman, University of Minnesota, St. Paul, Minnesota.

Vice President, N. J. Giddings, University of West Virginia, Morgantown, West Virginia.

Secretary-Treasurer, G. R. Lyman, United States Department of Agriculture, Washington, D. C.

Councillor for two years, I. E. Melhus, Iowa State College, Ames, Iowa.

Councillor for one year (to complete the unexpired term of Dr. Giddings), Harry B. Humphrey, United States Department of Agriculture, Washington, D. C.

Councillors for one year (chosen by the Divisions of the Society), W. H. Rankin, Dominion Laboratory of Plant Pathology, St. Catharines, Ontario, representing the Canadian Division; H. S. Reed, Citrus Experiment Station, Riverside, California, representing the Pacific Coast Division; and C. W. Edgerton, University of Louisiana, Baton Rouge, Louisiana, representing the Southern Division.

Members of the Editorial Board of Phytopathology (chosen by the Council of the Society): Editor for two years, L. L. Harter, United States Department of Agriculture,

Washington, D. C.; Associate Editors for three years, H. S. Fawcett, Citrus Experiment Station, Riverside, California; W. P. Fraser, University of Saskatchewan, Saskatoon, Saskatchewan; F. A. Wolf, North Carolina Agricultural College, West Raleigh, North Carolina; L. E. Melchers, Kansas Agricultural College, Manhattan, Kansas; Business Manager for one year, G. R. Lyman, United States Department of Agriculture, Washington, D. C.; Advertising Manager, R. G. Pierce, United States Department of Agriculture, Washington, D. C.

The Society voted to hold its next annual meeting at Boston, Massachusetts, December 26–30, 1922, in conjunction with the American Association for the Advancement of Science.

REPORT OF THE TREASURER FOR 1921

Receipts:		
Balance from 1920	$359.72	
Membership dues	2,873.58	
Subscriptions to Phytopathology included in checks for annual dues	130.00	
Contributions to Phytopathology deficit included in checks for annual dues	39.50	
Excess dues	14.00	
Exchange	1.26	
Interest	39.54	
		$3,457.60
Expenditures:		
Member subscriptions to Phytopathology	$1,926.00	
Secretarial work	89.57	
Stationery, stamped envelopes, printing	156.66	
Subscriptions included in checks for annual dues and transferred to Phytopathology account	130.00	
Contributions to Phytopathology deficit included in checks for annual dues and transferred to Phytopathology account	39.50	
Stamps	5.00	
Excess dues returned	14.00	
Duplicate dues returned	5.00	
Secretary-Treasurer's traveling expenses and miscellaneous expenses	49.61	
Supplies	5.30	
Checks returned by bank	27.06	
		2,447.70
Balance		$1,009.90
Sinking fund:		
Balance due fund from Society for 1920	$165.58	
Balance due fund from Society for 1921	535.00	
		700.58
Actual balance		$309.32

On December 20, 1921, the Society had 539 members in good standing—87 life sustaining and 452 regular, as opposed to 495 members at the close of 1920, or a gain of 44 during the year. During 1921 the Society lost two members by death, Miss Eunice R. Oberly and Mr. C. E. Kurtzweil. Twenty-nine candidates were elected to membership for 1922.

REPORT OF THE BUSINESS MANAGER OF PHYTOPATHOLOGY FOR 1921

Receipts:			
Balance from 1920		$255.96	
Member subscriptions		1,926.00	
Subscriptions received direct		1,165.23	
Sales made direct		303.25	
Subscriptions and sales through Williams & Wilkins Co.		880.31	
Advertising 1920		193.86	
Advertising 1921, part		30.68	
Illustrations, excess in Hotson article		20.00	
Contributions to Phytopathology deficit		1,059.72	
Interest on invested sinking fund		120.00	
			$5,955.01
Expenditures:			
Loan of Dec., 1920, repaid to American Phytopathological Society		$800.00	
Manufacturing Phytopathology:			
Vol. X, No. 10	$200.92		
Vol. X, No. 11	421.01		
Vol. X, No. 12	372.46		
	$994.39		
Vol. XI, No. 1	369.60		
Vol. XI, No. 2	334.43		
Vol. XI, No. 3	366.26		
Vol. XI, No. 4	296.84		
Vol. XI, No. 5	190.09		
Vol. XI, No. 6	150.40		
Vol. XI, No. 7	372.40		
	2,080.02	3,074.41	
Miscellaneous Journal Expenses		66.29	
Secretarial work		116.23	
Supplies		9.85	
Excess subscriptions returned		3.26	
Rebate on sales of Phytopathology		4.50	
Printing		57.09	
Miscellaneous expenses of Advertising Manager		5.74	
Postage		15.00	
Checks returned by bank		104.00	
			$4,256.37
			$1,698.64

Sinking fund:			
Amount invested		$2,000.00	
Due sinking fund from Society			
from 1920	$165.58		
from 1921	535.00		
		700.58	

An auditing committee, consisting of Mel. T. Cook and E. M. Massey, was appointed to examine the accounts of the treasurer and business manager. This committee reported the accounts correct and the reports were adopted.

PHYTOPATHOLOGY

At the phytopathologists' dinner on Thursday evening the business manager of Phytopathology made the following report:

"The past year has been an important one in the history of Phytopathology. At the Chicago meeting the business manager reported a rapidly increasing deficit due to the steadily mounting cost of manufacturing the journal. To meet this emergency it was determined to adopt the plan which has been put into operation the past year as follows:

"1. Printing costs have been reduced. Relations with Williams & Wilkins Company of Baltimore, Maryland, our publishers for many years, were terminated and arrangements made with the Intelligencer Printing Company of Lancaster, Pennsylvania, to manufacture Phytopathology, beginning with the January number of 1921, at a considerable reduction in cost. Relations with the new firm have been entirely satisfactory. Unfortunately, the printers' strike forced the Intelligencer Printing Company to break in a new staff of operatives, resulting in a great delay in publication, but we are now rapidly catching up and shortly Phytopathology should be appearing on schedule time.

"2. Other expenses have been reduced, due to members of the Society assuming certain obligations. Formerly, Williams & Wilkins Company handled subscriptions, advertisements, and the sale of back volumes on a percentage basis. All matters relating to subscriptions are now handled by the business manager. Mr. Roy G. Pierce was appointed advertising manager and under his supervision the revenue from advertisements during 1921 exceeded the customary receipts from Williams & Wilkins Company, although the year has been one of great business depression. Through the courtesy of President A. F. Woods, the back volumes are now stored free of charge. in one of the fireproof buildings of the University of Maryland, with Professor C. E. Temple in charge. These changes have resulted in material savings.

"3. Revenues have also been increased, due to the hearty coöperation of our whole membership in securing new subscribers and new members of the Society. Fifty-five new members have been received and their names added to the mailing list of Phytopathology during 1921, and in addition twenty-nine others begin their membership with 1922.

"During 1920 Phytopathology had been obliged to borrow $1375.00 to meet current expenses. In addition there were bills due Williams & Wilkins Company amounting to $1060.68. Deducting $255.96, the cash balance on hand, there remained an indebtedness of $2179.72 on December 31, 1920. At Chicago the Society appropriated $575.00 from its treasury, and our members, voluntarily contributed $1059.72 toward paying this deficit, making a total of $1634.72. There still remained an indebtedness of $545.00 which Phytopathology had to carry as it entered on the new plan of operation in January, 1921.

"The saving effected under the new plan, together with the increased revenue outlined above, have enabled the journal to wipe out this deficit and the business manager takes pleasure in reporting that today Phytopathology is not only free of debt, but there is sufficient money on hand to pay for the remaining issues of 1921, making a volume of approximately 520 pages, with a small balance remaining in the bank. Every dollar of revenue for 1922, therefore, can be devoted to paying 1922 expenses. This means that we shall be able to continue issuing 500 to 600 pages annually, notwithstanding present high printing costs. The liquidation within one year of an indebtedness of $2179.72 is convincing proof of the loyalty of this Society to its official journal."

PROGRAM OF THE ANNUAL MEETING

At the annual dinner consideration was also given to the steadily increasing congestion of the program, as shown by the presence of 49 papers on the program at St. Louis, 80 at Chicago, and 97 at Toronto. This increase is natural in view of the steadily growing membership of the Society and still further increase is to be expected. It was voted, therefore, that at future annual meetings the Secretary be authorized to schedule simultaneous sessions when necessary. To relieve the congestion further and to permit more effective handling of the program, it was voted that members be requested not to submit titles and abstracts in case they have no expectation of attending the meeting. It was also voted that the printing of abstracts be continued, with any modification from the present practice which in the judgment of the Council may be necessary in the interest of economy.

REPORT OF THE ADVISORY BOARD

The Advisory Board reported through its chairman, G. R. Lyman, on the work of the year.

The third annual summer meeting of the Society was held at St. Paul, Minnesota, and Fargo, North Dakota, July 19–22, 1921, in conjunction with the conference of cereal pathologists. Members of the Society were present from the Philippine Islands, Saskatchewan, Manitoba, and Ontario, Canada, and from ten states. There were present as guests of the Society Dr. E. J. Butler, Director of the Imperial Bureau of Mycology, London; Dr. Kingo Miyabe, Director of the Botanical Garden, Hokkaido Imperial University, Sapporo, Japan; Mr. R. J. Noble and Mr. James P. Sheldon, Department of Agriculture, New South Wales, Australia. Professor A. Jaczewski, Director of the Institute of Mycology and Phytopathology, and Professor N. I. Vavilov, Director of the Bureau of Applied Botany and Plant Breeding, both of Petrograd, Russia, arrived in America too late to attend the conference, but made an extended tour of the United States and Canada before returning to Russia.

Plans for the 1922 field meeting are developing rapidly. This meeting will be devoted to diseases of vegetables and will be held the latter part of August in the vicinity of Philadelphia.

The 1920 list of active phytopathological projects was issued during the year. The tardy responses of pathologists to requests for data indicate that the Society is not sufficiently interested in this list to warrant its continuance as an annual affair.

Dr. E. M. Freeman, chairman of the committee on the Phytopathological Institute, reported that certain prospective sources of funds have been investigated, but that the year has been an exceedingly bad one for the solicitation of money. Nevertheless we should keep this project actively before us, as its ultimate realization is by no means hopeless. At Dr. Freeman's request, he was relieved of the chairmanship of this committee and Dr. E. C. Stakman was appointed in his place.

The Advisory Board has continued to serve as the committee on phytopathology of the Division of Biology and Agriculture of the National Research Council. The most important matters considered in this connection during the year related to the Crop Protection Institute, Phytopathological Research in Tropical America, and the publication of the Farlow Bibliographical Index.

F. D. Fromme, C. R. Orton, and G. H. Coons have served as representatives of this Society on the Board of Governors of the Crop Protection Institute. This committee met with other members of the Board of Governors in Rochester, N. Y., last January and outlined a coöperative project on dusting fruits and vegetable crops for the con-

trol of diseases and insect pests. This project has been carried out in Connecticut, New York, Pennsylvania, and West Virginia under the leadership of Dr. N. J. Giddings. Some notable results were secured bearing on the control of both diseases and insects and a general summary of these results has been published in the Crop Protection Digest, vol. I, no. 2. A research project upon sulphur in its elemental and compound forms as it affects fungi and insects and as it is affected by meteorological and soil conditions, has been formulated and will be presented for approval at the next meeting of the Institute to be held at Rochester, January 12, 1922. Financial support for this project will be sought from the industries concerned, and a sufficient sum of money will be requested to establish fellowships for fundamental investigations. There is good prospect that the work will be adequately financed and that it will be initiated in the near future. Dr. Coons' term of service on the Board of Governors having expired, he was chosen by the Advisory Board to succeed himself for a term of three years.

During the past year there was organized, under the auspices of the National Research Council, The Institute for Research in Tropical America, with the object of fostering biological and other scientific investigations in the American Tropics. The American Phytopathological Society being eligible to membership in this Institute, the Council selected Dr. W. A. Orton as its representative. Dr. Orton has also served during the year as chairman of the committee of the National Research Council on Phytopathology in the Tropics, the other members of the committee being I. W. Bailey, L. R. Jones, John R. Johnston, G. R. Lyman, S. C. Prescott, Otto Reinking, and W. H. Weston, Jr. Under the auspices of the National Research Council, Dr. Orton visited Florida, Cuba, and the Bahama Islands in January and February, 1921, to investigate the need and desirability of establishing a tropical phytopathological laboratory. As a result he has recommended to the National Research Council and to the Institute for Research in Tropical America that such a laboratory be established in southern Florida. A further step toward the establishment of headquarters for tropical plant work in Florida has been taken by the Board of Control of the University of Florida, which has decided upon the establishment of a School of Tropical Agriculture at some point to be selected. Further developments in the establishment of a research center in southern Florida may be expected during the coming year.

Negotiations looking toward the publication of the Farlow Bibliographical Index are progressing under the leadership of Dr. L. R. Jones of the National Research Council, and although no definite statement can yet be made, the prospect of securing funds for publication is becoming more favorable.

REPORTS OF COMMITTEES

The Committee on Standardization of Biological Stains.—Dr. R. H. Colley, who had been temporarily appointed by the president of the Society to confer with Dr. H. J. Conn, Chairman of the Committee of the Society of American Bacteriologists on Standardization of Biological Stains, and to determine how the Society could aid that committee in its work, made a report on the present status of the biological stain situation in this country. He stated that the standardization work, formerly carried on by a committee of the Society of American Bacteriologists, had been taken over and put on a broader basis by the National Research Council, and recommended that the Society take some definite action defining its attitude toward further coöperation during the coming year. Dr. Colley was elected to represent the Society before the new committee of the National Research Council, to report to this committee the results of experiments on the use of American stains, and to assist the members of the Society

with information on such results and on the sources of American stains. Inasmuch as the success of this work depends absolutely on the coöperative attitude of the members of the Society, all are requested to report the results of their experiments on American-made stains to Dr. Colley, Forest Pathology, Old Soils Building, University of Wisconsin, Madison, Wisconsin, in order that the results may be correlated and the information made available for members of the Society and for report to the central committee.

The Committee on the F. Köplin Ravn Fellowship reported through its chairman, Dr. L. R. Jones, that it has been in correspondence with the American Scandinavian Foundation of New York City and is assured of their sympathetic interest in this project. It has also had personal conferences with Dr. C. Ferdinandsen, Dr. Ravn's successor in Denmark, who advised that funds are being raised there for some form of memorial. It seems probable that some progress may be made toward the desired fellowship through the coöperation of these two agencies, possibly supplemented by the securing of additional funds in America. On motion the report was accepted and the committee continued.

The Committee on Standards and Methods made no formal report, and on motion it was voted that it be discharged from further service.

PROPOSED FEDERATION OF BIOLOGICAL SOCIETIES

At the request of a number of botanists and zoologists Dr. L. R. Jones, as chairman of the Division of Biology and Agriculture of the National Research Council, invited the presidents and secretaries of all biological societies meeting at Toronto to attend a conference on Tuesday, December 27, at the King Edward Hotel, to consider the advantages and feasability of some sort of federation of biological societies. Among the advantages to be secured by such a federation were mentioned the more effective coördination of meetings and programs, and the pooling of society publications. After extended discussion the following resolutions were unanimously adopted:

Resolved, That it is the sense of this conference that an inter-society conference should be called to study and report upon the feasibility of federation of the biological societies and to develop plans for the said federation.

Resolved, That for the purpose of effecting such an organization each society and Sections F and G of the American Association for the Advancement of Science be requested to designate its president and secretary as members of an inter-society council which shall be authorized (1) to deal with all matters of common interest, such as pooling of programs, that are consistent with the existing regulations of the constituent societies; and (2) to draw up proposals for a constitution and by-laws of a federation of the societies in question and to present them for action at the next annual meetings of the societies.

The American Phytopathological Society designated Doctors Reddick and Lyman as its representatives at the proposed inter-society conference.

RESOLUTIONS

On motion a committee on resolutions, consisting of E. C. Stakman, J. E. Howitt, and C. R. Orton, was appointed by the president. This committee reported the following resolutions, all of which were unanimously adopted:

1. *Demise of Eunice R. Oberly:*

The sudden and unexpected death of Eunice R. Oberly on November 5, has brought a feeling of personal loss to every member of the Society and sorrow to that large proportion of our membership who had the privilege of personal acquaintance with her and who have been helped by her kindliness, efficiency, and wide acquaintance with

the literature of our subject. Although she was not a member of the editorial board of Phytopathology, Miss Oberly was a great source of help to the editors of the journal and to the Society, not only as advisor on various bibliographical technicalities, but also as the originator and early compiler of the monthly lists of "Literature on Plant Diseases," which came to be known popularly as the "Oberly list."

This expression of esteem for a colleague and friend, cut off in the midst of her achievements and plans, is inscribed with sorrow upon the Minutes of this Society.—L. R. Jones, W. A. Orton, and D. Reddick, Special Committee.

2. *Demise of Carl Kurtzweil:*

It is with deep regret and a keen sense of loss that the American Phytopathological Society takes official cognizance of the untimely death in May of one of its younger members, Carl Kurtzweil, an able and enthusiastic investigator and a splendid young man;

Therefore, be it Resolved, That the Secretary of the Society be instructed to send to Mr. Kurtzweil's family, expression of our sincere sympathy.—Olaf S. Aamodt, L. R. Hesler, and E. C. Stakman, Special Committee.

3. *Demise of Giuseppe Cuboni:*

The American Phytopathological Society, in annual convention assembled, expresses regret at the passing of November 3, 1920, at Rome, of the venerable plant pathologist, Dr. Giuseppe Cuboni. Active for more than forty years as an investigator, and productive throughout his life, Dr. Cuboni has long been known to the scientific world for his important contributions to mycology and vegetable pathology. The Society extends condolences to his co-workers in the Reale Stazione di Patologia Vegetale and to his colleagues in Italy.

4. *Eunice R. Oberly Memorial Prize:*

Whereas, A movement is under way to procure funds for a Eunice R. Oberly Cash Memorial Prize, to be granted annually for the stimulation and recognition of excellence in bibliographical work:

Therefore, be it Resolved, That we, the members of the American Phytopathological Society, concretely show our appreciation of Miss Oberly's work by contributing as individuals such sum as may be designated by the Council.

5. *Publications of the Department of Agriculture:*

Whereas, The discontinuance of the publication of the Journal of Agricultural Research and of the Experiment Station Record is a serious blow to scientific progress and international relations;

Therefore, be it Resolved, By the American Phytopathological Society that our retiring president be directed to transmit our views to the proper authorities.

6. *Bacterial nomenclature:*

Whereas, The Society of American Bacteriologists has adopted uniform rules for nomenclature of bacteria about which the American Phytopathological Society is poorly informed, but in which it is deeply interested;

Therefore, be it Resolved, That a special committee be appointed to study the situation and report at the next annual meeting.

7. *Distribution by cultures of plant pathogenes:*

Whereas, There is properly constituted authority to prevent by quarantine the spread of destructive diseases; but

Whereas, It is impossible for any official agency to control adequately the distribution of cultures of virulent pathogenes;

Therefore, be it Resolved, That we, the members of the American Phytopathological Society, use the utmost discretion in transportation and disposition of such cultures.

8. *Thanks to citizens of Toronto and authorities of Toronto University:*

The American Phytopathological Society wishes to express to the citizens of Toronto and to the University authorities its deep appreciation and sincere thanks for the courtesies and hospitality extended during the meetings of the Society, and especially do the members from the United States wish to thank the President of the Canadian Branch, Dr. Faull, and all the other officers and members of the Branch Society for their untiring zeal in making our meeting so pleasant and profitable. We wish to urge, furthermore, that our Canadian brethren accept this inadequate formulation of our feelings, not as a merely traditional formality, but as an honestly sincere expression of real gratitude.

9. *Thanks to the Officers of the American Phytopathological Society:*

Whereas, The officers of the American Phytopathological Society have sacrificed much personal peace and comfort during the last year and have earnestly and devotedly labored for the general weal;

Therefore, be it Resolved, By the "hoi polloi" that we express our appreciation and thanks to all the officers of the Society and that we wish them a happy, prosperous, and unpersecuted New Year.

MISCELLANEOUS BUSINESS

The secretary's report of the twelfth annual meeting held at Chicago, as published in Number 4, Volume 11 of Phytopathology, was adopted without correction.

President Reddick read a communication from Italy, inviting contributions to a memorial in Rome to Doctor Giuseppe Cuboni, late Director of the Reale Stazione di Patalogia Vegetale. On motion the president was authorized to send a contribution of $25.00 in the name of the Society, assessing the principal phytopathological centers sufficient sums to make up the amount named.

In accordance with the resolution adopted by the Society, the president appointed as a committee on bacterial nomenclature, Dr. Erwin F. Smith, chairman, Dr. L. R. Jones, and Dr. Ernst A. Bessey.

It was voted that the president appoint a committee of two to act with the representatives of this Society on the Board of Governors of the Crop Protection Institute on the dissemination of plant diseases by seed. Dr. M. F. Barrus and Dr. M. T. Munn were appointed on this committee.

President Reddick received a cablegram from Doctors Quanjer and Westerdijk, stating that plans were being made to hold a field conference in Holland during May, 1922, and inquiring whether representatives of American phytopathologists and entomologists could be present. Upon motion the matter was referred to the Council, with authority to appoint as delegates any members of the American Phytopathological Society who could attend the Holland conference.

ACTION OF THE COUNCIL

The Council reported the following action for the information of members of the Society:

Representatives on the Council of the American Association for the Advancement of Science.—In accordance with the custom of other societies, the president and secretary of the American Phytopathological Society have acted as our representatives on the Council of the A. A. A. S., but the official duties of officers of the Societies so seriously interfered with their attendance at meetings of the Association Council that the societies were requested to designate persons other than their officers as their representatives. In accordance with this request Dr. Mel. T. Cook and Dr. C. L. Shear were named representatives of the American Phytopathological Society.

Advisory Board.—The Council selected Dr. J. H. Faull to succeed Dr. A. H. R. Buller as Commissioner for Canada, and Dr. R. J. Haskell to succeed Dr. G. R. Lyman as Commissioner for the United States Department of Agriculture.

The Eunice R. Oberly Memorial Prize.—After discussion of this matter, which was referred to it by resolution adopted by the Society, the Council directed the Secretary-Treasurer in sending out the notices of annual dues next fall to request each member of the Society to add twenty-five cents to his check as a personal contribution toward the fund for the Oberly Memorial Prize.

Phytopathology.—The Council recognized the importance and weight of the responsibility resting on the editor-in-chief of Phytopathology and the practical difficulties in the way of his securing any large measure of assistance from the other members of the editorial board. It was determined, therefore, to continue selecting the associate editors on the basis of regional representation as at present, but, in future to choose the other two principal editors in consultation with the editor-in-chief for terms coextensive with his own, in an effort to constitute a central editorial committee of maximum assistance to the editor-in-chief.

G. R. LYMAN, *Secretary.*

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